Face Recognition Using a Facial Recognition System

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Summary
Facial recognition system is a biometric manipulation. Its applicability is simpler, and its work range is broader than fingerprints, iris scans, signatures, etc. The system utilizes two technologies, such as face detection and recognition. This study aims to develop a facial recognition system to recognize person's faces. Facial recognition system can map facial characteristics from photos or videos and compare the information with a given facial database to find a match, which helps identify a face. The proposed system can assist in face recognition. The developed system records several images, processes recorded images, checks for any match in the database, and returns the result. The developed technology can recognize multiple faces in live recordings.

Keywords:
Facial recognition; face detection; feature extraction; person's identity.

1. Introduction

Face recognition system is considered an application of facial image processing and has recently gained popularity due to its ease of use or non-invasiveness [1]. This system is intensively studied and used to establish different models for more accurate results [2]. It uses human biometric information and can replace other fingerprints, irises, signatures, etc. [3-4]. Facial recognition systems are commonly used in the big cities for security purposes, video surveillance, personal authentication, and similar security activities [5-6]. These are complicated image processing issues, with complex effects of lighting, imaging conditions, and occlusion on live images [7]. The recognition application uses images and recognition algorithms to recognize faces and extract facial images, such as eyebrows, eyes, mouth, and nose, making the algorithm more complex than a single detection and detection algorithm. In a facial recognition system, the 1st step is to capture an image from the camera. The 2nd step is captured image's face recognition. In the 3rd step, face recognition is performed, which uses a facial image from the output of the detection portion. The last step is the individual's identity [5, 8].

Figure 1 shows a diagram of the procedure for a face recognition system.

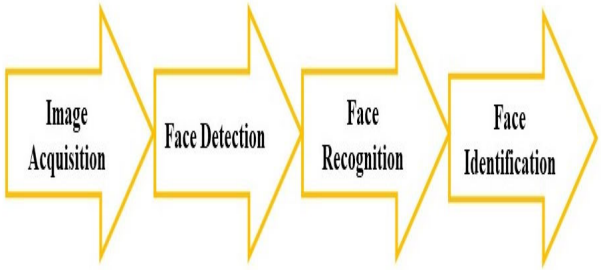

Fig. 1 Steps of face recognition.

Researchers have discovered that artificial intelligence (AI) sensors, trackers, and data analytics are used in smart homes, cars, classrooms, and workplaces. Facial recognition determines most matches with sub-probability and certain similarity thresholds [9]. Face recognition is a smaller biometric method with high resolution and low sniffing characteristics. Facial recognition has attracted researchers' attention in the fields of security, psychology, and image processing since the early 1970s [10]. Various algorithms were suggested for detecting faces [11-12]. Face recognition is one of the visual tasks that can be performed by humans easily, but it is not an easy task from a computer version perspective. A general description of the problem can be defined as detecting and identifying an unknown number of faces (if any) in still or video images. Solutions to this problem include segmenting, extracting, and verifying faces, and in some cases, facial features against uncontrolled backgrounds. As a visual front-end processor, facial recognition systems can perform tasks regardless of lighting, orientation, or camera distance. Chellappa et al., (1995) investigated several issues, such as segmentation and feature extraction related to face recognition [12]. Face recognition is considered a simplified image analysis and pattern recognition application. There are at least two reasons to understand this trend [13], including various commercial and legal inquiries and the availability of related technologies (smartphones, digital cameras, GPUs, etc.). Nowadays, facial recognition, in combination with AI technology, makes it possible to identify people based on their faces. Face recognition analyzes other biometric details, such as facial features and eyes, and compares them

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to photos and videos. Face recognition methods generally extract the facial characteristics of individuals and compare them to a stored database to get potential matches [14]. According to a report [9], the facial recognition market is valued at $ 4.4 billion globally in 2019 and is estimated to go over $ 10.9 billion in 2025. This technology is already used in some countries like China and the USA. It is also available in other countries, such as Saudi Arabia and UAE [15]. The aim of this study is to build a face recognition system using face detection by developing a facial recognizer and testing and validating the developed model.

2. Materials and Methods

2.1 Face Verification Algorithm

Face tracking, facial expression recognition, gender classification, facial feature extraction, clustering, digital cosmetics, alert user interface, and measurement systems in face recognition may help to build an effective face identification model. The majority of facial recognition algorithms can be expanded to recognize vehicles, people, pedestrians, signs, etc. Data mining includes the analysis of large groups of data to manage and manipulate new patterns and methods in the database using complex algorithms provided by the MATLAB program. MATLAB provides tools for data retrieval, analysis, and visualization. Users can document and share their results via graphs, reports, or codes written in MATLAB. In this study, MATLAB is used to develop a customized algorithm to explore, retrieve, collect, and analyze data through complex algorithms, such as machine learning, mining, and computing resources.

2.2 Face Verification Technique Directions

The method of implementing a face recognition system utilizing MATLAB is the eigenvector-based recognition system method. We have prepared a dataset of 40 people. Each person has 10 pictures taken in different poses, which means that there are 40 x 10 = 400 images. Each of them has a separate volume. Figure 2 represents face recognition preparation using MATLAB. Forty people are marked as 1, 2, 3 to 40 in the upper row.

Step 1: Data set setup
Ten grayscale photos for each person are taken, and one folder is created per person. Images must be of the same resolution and dimensions.
A photo of 92 x 112 pixels is taken. The image name must be numeric, such as 1, 2, and 3. Images must have the same extension as bmp, pgm, etc.

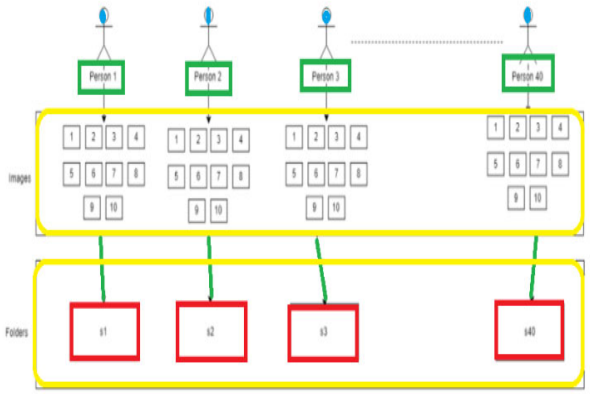

Fig. 2 Face recognition preparation using MATLAB.

Step 2: Dataset downloading
Database loading can be illustrated in Figure 3.

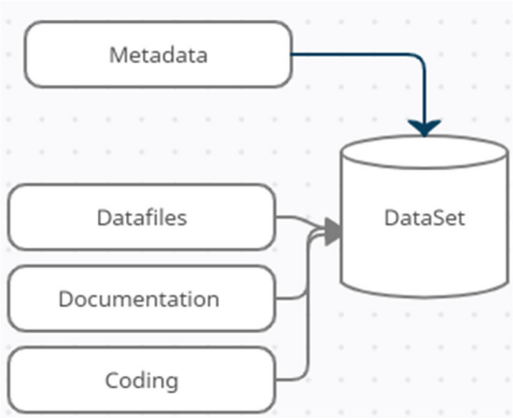

Fig. 3 Database loading.

The second step is to load the dataset. A function is implemented in MATLAB that loads the dataset. This function can also be used to load another dataset. The file name is loadDB.m.

```
loaded_Image=loadDB();
random_Index=round(400*rand(1,1));
random_Image=loaded_Image(:,random_Index);
rest_of_the_images=loaded_Image(:,[1:random_Index-1
random_Index+1:end]);                image_Signature=20;
white_Image=uint8(ones(1,size(rest_of_the_images,2)));
mean_value=uint8(mean(rest_of_the_images,2));
mean_Removed=rest_of_the_images-
uint8(single(mean_value)*single(white_Image));
L=single(mean_Removed)'*single(mean_Removed);
[V,D]=eig(L); V=single(mean_Removed)*V; V=V(:,end:-
1:end-(image_Signature-1));
all_image_Signatire=zeros(size(rest_of_the_images,2),ima
ge_Signature);      for      i=1:size(rest_of_the_images,2);
```

```
all_image_Signatire(i,:)=single(mean_Removed(:,i))'*V;
end subplot(121);
imshow(reshape(random_Image,112,92)); title('Looking for this Face','FontWeight','bold','Fontsize',16,'color','red');
subplot(122); p=random_Image-mean_value;
s=single(p)'*V; z=[]; for i=1:size(rest_of_the_images,2)
z=[z,norm(all_image_Signatire(i,:)-s,2)];
if(rem(i,20)==0),imshow(reshape(rest_of_the_images(:,i),
112,92)),end; drawnow; end [a,i]=min(z); subplot(122);
imshow(reshape(rest_of_the_images(:,i),112,92));
title('Recognition
Completed','FontWeight','bold','Fontsize',16,'color','red')
```

In the first line, the function's name is loadDB. It does not take any input. It returns a numeric form of images. The image is saved in a variable named ‘ouput_value’. Two variables namely ‘loaded’ and ‘numeric_Images’ are taken. The variables are known to be persistent types. In the "if" situation, several actions should be taken as follows: It should be checked whether the 'loaded' variable is null. If it is empty, then the dataset is reloaded. The continuous variables are used to store the data.

Step 3: Face recognition data

The dataset is loaded first, and then a random function is used to create a random index. The random index sequence is used to load an image recognized later. The rest of the photos are loaded in different variations. The average of all the images is calculated. The eigenvectors are then calculated on these images. A matrix is created where each row includes the signature of the individual image.

2.3 Feature Extraction

The face image is thought of as a two-dimensional array of pixel values and numbers. It can be expressed as: where S means square grid. It is more appropriate to express X as a one-dimensional column vector of a series of pixels, X = [X1, X2, ……, XN] T, where N I means the total number of pixels in the image. N means 76800 for a quarter of a Video Graphics Array (VGA) image (320 x 240). This high-dimensional feature is generally ineffective and lacks the ability to distinguish. X is converted into a characteristic vector f (X) = (f 1(X), f2 (X), ..., fM (X)] T, where f1 (X) and f2 (X), are linear and nonlinear functions. M is much smaller than N.

2.4 Face Verification Stages

A verification algorithm has several stages: Detection Stage: The image of the person identified is taken in the crowd, using a pre-available image, subtracting it from the video clip, or capturing it by the door camera. Alignment Stage: After taking the photo, the system determines the position, size, and orientation of the head. When recognition is performed using a "three-dimensional" video camera, it is possible to determine this even if the image is in landscape orientation. It will be 90 degrees. For 2D images, the curvature between the face and the camera should not exceed 35 degrees. Measurement Stage: The system software calculates facial curves and curves less than 1 millimeter. Then, this information is converted into a face template to extract the salient features of the physiological and behavioral features and place the template in the database of "information". Representation Stage: In this step, the system transforms the template into a code consisting of a series of numbers that represent the attributes of the template. Matching Stage: Facial feature data are processed into formulas that allow the program to compare images to a database containing many images. Verification/Identification Stage: A few seconds are taken to determine the correspondence between the image and the image in the system database. Figure 4 illustrates the stages of applying the face verification technique.

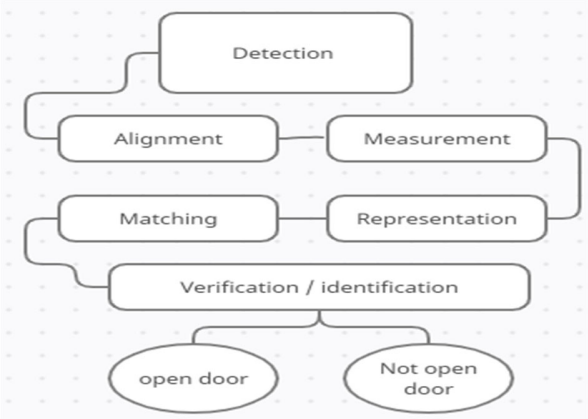

Fig. 4 Face verification stages.

2.5 Face Recognition

Using the isosceles triangle approach, mouth and eyes are obtained. Then, the face image is trimmed. A database of the images of faces can be produced. This database is built from the part of face detection. Then, Pattern Recognition Tool from the Neural Network Toolbox is utilized to prepare the neural network. The network includes 10 layers along with a sigmoid transfer function. The 10 layers include the hidden layer and the output layer. The output layer includes 40 neurons. The numbers of hidden layer neurons are 400. Face detection and recognition sections are combined to employ a face recognition system. The system can manage one or more faces in the obtained image. The code is then built on the program. The results are displayed in Figures 5 and 6, respectively.

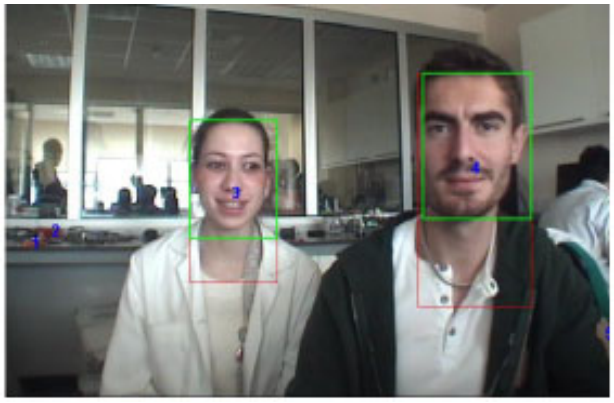

Fig. 5 Acquired image and the candidates [5].

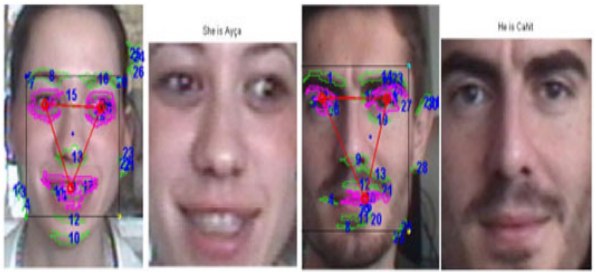

Fig. 6 Feature extraction from the face image [5].

The algorithm can get various faces in the recorded image and categorize them correctly. When the eyelashes are closed, an image is taken. The recognition's overall accuracy is 99.0498. If the system identifies faces, network outputs are 52.7422 (maximum) for one person and 1.3872 (minimum) for another person. This algorithm identifies face if the network's output is more than 90. Several experiments are conducted on live photos. Face recognition and detection elements perform efficiently. Skin segmentation lowers the computational time and seeks a place for the face. Connection is established correctly among recognition and detection portions. The network efficiently categorizes when eyes are closed and eyebrows are moved. There is a smile on the face, or the teeth are visible. Various human images in the database may be multiplied and maximum in all likelihood, classifying faces efficiently. 2.6 Face Verification Algorithms MATLAB version R2012a or higher version is installed in the system and then launched from the desktop shortcut. A blank command window is shown.

Then, the source folder is downloaded. The device ID is checked, as shown in Figure 7, and the device ID number is written in the source code.

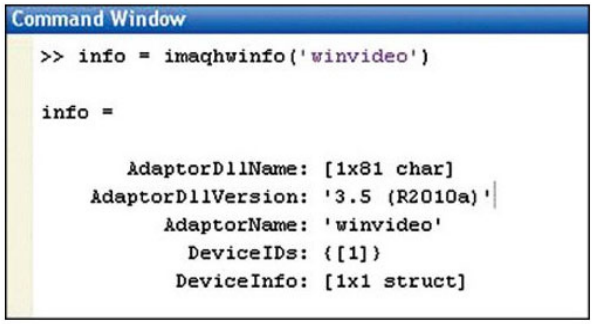

Fig. 7 Checking the device ID [16].

The program is run. A GUI is appeared, as shown in Figure 8.

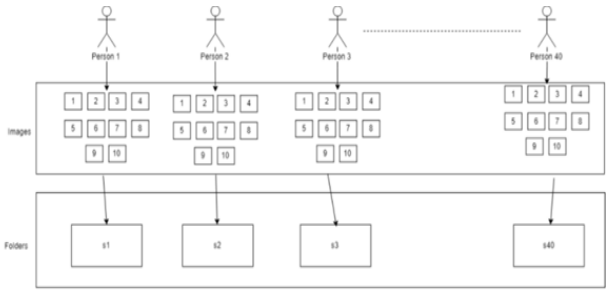

Fig. 8 The main interface of the program.

The start button is clicked to initialize camera settings. Then, the face button is clicked, and the face is detected by a camera and displayed on the right side of the screen (Figure 9).

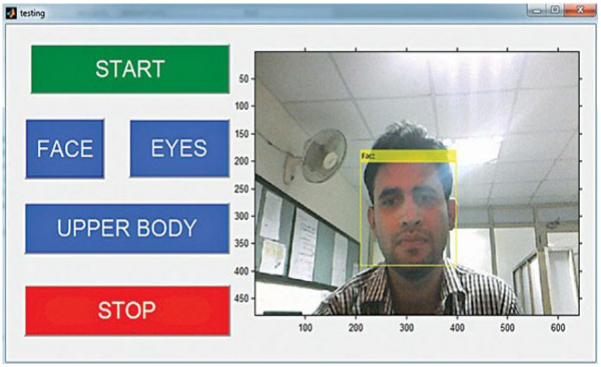

Fig. 9 Face detection [16].

Similarly, the system can detect the eyes and upper body by clicking on the respective buttons (Figure 10).
The stop button must be clicked to stop the previous process to detect the other two features. The stop button is clicked to terminate. A total of 40 people are organized in the dataset.

Each has 10 photos with different poses. This in turn gives 40*10 = 400 photos. For each individual, there is a separate folder. Figure 11 helps in preparing the dataset.

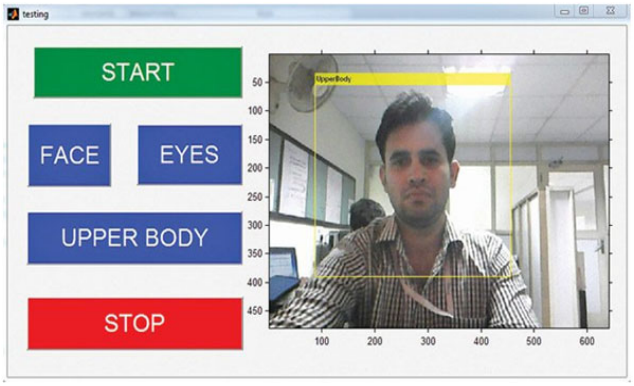

Fig 10 Detection of the upper body [16].

Fig. 11 Dataset preparing for face detection in MATLAB [16].

3. Results and Discussion

3.1 Results

This software automatically loads a photo (until we select to load a particular photo) after locating a photo of the equal person from the photo dataset. This study suggests that face recognition includes some separate procedures, which include a few methods specialized for faces. Faces are represented in an extra holistic way than different items, which produces particular representations of each feature and its configuration. Damage or developmental failures affecting neural regions concerned with face recognition can result in face recognition deficits and maximum prosopagnosia [17]. The usage of face verification strategies is one of the maximum promising important strategies in AI technology, which uses the capacity of synthetic intelligence for deep learning. When rotating and resizing the photo, it does not impact detection. After adjusting the color, the face cannot be detected. The set of rules relies upon the educated cooler. If there are numerous colors, the popularity cannot be done effectively. Color has nothing to do with operations, such as rotation and resizing. There are four examples of images obtained by the developed software (Figure 12).

3.2 System Evaluation

Face recognition accuracy is one of the major factors affecting the quality of the face recognition algorithm [18]. The accuracy of this approach is around 94%. Out of 100 trials, it can make 4 mistakes. The automatic facial recognition and detection device may be used for easy surveillance programs, inclusive of jail door and front security. Since there are managed situations when accumulating mugshots, the front-going through recognition scheme needs to show a higher discrimination accuracy than the effects received in this study, which are carried out below adverse situations. Furthermore, the various looks at topics do not show an expressionless frontal view on the device. In mugshot matching packages, the best recognition accuracy or a specific fit is not the requirement. If a face recognition device can reduce the wide variety of pictures that a human operator, it may produce a high-

Fig. 12 Example images obtained by the developed software [19]. © 2001 AT&T Laboratories Cambridge

quality realistic output to use in regulation enforcement. There are several parameters, which can be used to differ the descriptor's complexity: a variety of orientations, r, in the histograms, and the width, n, of the n×n array of orientation histograms. The descriptor vector size indicates the complexity of the descriptor. It can differentiate better in a huge database. However, it is more sensitive to form distortions and occlusion. Figure 13 indicates study outcomes wherein the wide variety of orientations and length of the descriptor varies. The graph changes into generated for a point of view transformation wherein a planar floor is tilted through 50 levels far from the viewer, and 4% photo noise is added.

Figure 13 indicates the percentage of key factors giving the right match to a 40,000 key factor-database as a function of the width of the n × n key point descriptor and the wide variety of orientations in every histogram. The graph is processed for pictures with an affine point of view alternate of 50 degrees and the addition of 4% noise.

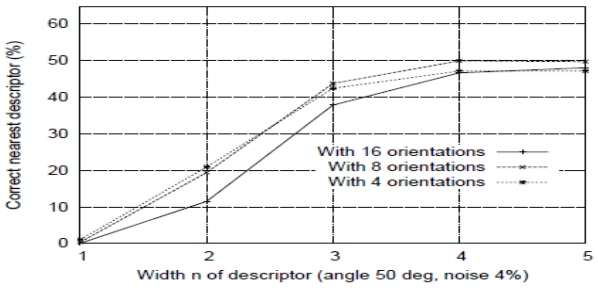

Fig. 13 Percentage of key factors.

This is close to the boundaries of dependable matching. The effects show the percentages of key factors that discover an accurate fit to the single closest neighbor. The graph suggests that a single orientation histogram can be bad at distinguishing. However, the effects maintain to enhance a 4x4 array of histograms, including eight orientations. Including extra orientations or a bigger descriptor can make it difficult to match by making the descriptor extra touchy to distortion. These effects have been widely compared for different ranges of points of view, extrude, and noise. In a few less difficult instances, discrimination persists in enhancing (from already excessive levels) with 5x5 and better descriptor sizes. of 4% noise. We have used a 4x4 descriptor along with eight orientations, and characteristic vectors are ensured with 128 dimensions. If the descriptor's dimensionality is high, it constantly performs higher than lower-dimensional descriptors on a variety of matching duties [20]. In addition, the computational cost of matching is low when applying the nearest-neighbor method. Face recognition is considered one of the most successful image analysis and processing applications. Face recognition is based on face descriptors. The similarity between the entered face descriptor and all face descriptors previously stored in the gallery is calculated. Facial recognition systems are ideal for preventing crime and providing real-time actionable intelligence to persons. Fidelity and scalable software provide dynamic monitoring and facial recognition capabilities on mobile and desktop devices to track people' movements and identify and block unwanted visitors and complex cases. This technology extracts and processes biometric data by creating a "biometric template" [12]. For facial images, biometric templates recognize and measure various facial features [11]. Many researchers designed facial recognition systems in their studies. Gürel and Erden, (2012) have designed a face recognition system and found that the tested system shows an acceptable performance in recognizing faces [5]. The system can successfully detect and recognize multiple faces in live acquired images. In a previous study, a face recognition application was developed for a biometric system based on Convolutional Neural Networks. The researchers proposed a structure of a deep learning model, which allows the improvement of processing time and the existing state-of-the-art precision [14]. Diyasa et al., (2021) have detected multiple prisoners' faces in jail by combining deep neural networks, including Convolutional Neural Networks (CNN) and Haar Cascade Classifier, as real-time facial recognition, which has been very efficient in face classification (accuracy rate of 87%) [21]. In this study, a face recognition system has been designed, which also has a higher accuracy rate.

4. Conclusion

In this study, a proposed facial recognizer approach has been developed. The system can map facial features from videos and photos and compare the information with a given facial database to locate a match, identifying a person's face. The proposed system is believed to assist in face recognition. The developed system has an acceptable performance. It can also recognize multiple faces in live recordings. The percentages of key factors give the right match to the 40,000 key factor-database.

References

[1] Lin, S.-H.: *An Introduction to Face Recognition Technology*. Informing Science (Multimedia Informing Technologies) 3(1), 7 (2000).

[2] Virmani, D., Girdhar, P., Jain, P., Bamdev, P.: *FDREnet: Face Detection and Recognition Pipeline*. Engineering, Technology & Applied Science Research 9(2), 3933–3938 (2019).

[3] Salamh, A. B. S., Akyüz, H. I.: *A Novel Feature Extraction Descriptor for Face Recognition*. Engineering, Technology & Applied Science Research 12(1), 8033–8038 (2022).

[4] Zhou, L., Wang, H., Liu, W., Lu, Z.-M.: *Face Feature Extraction and Recognition via Local Binary Pattern and Two-dimensional Locality Preserving Projection*.

Multimedia Tools and Applications 78(11), 14971–14987 (2019).
[5] Gürel, C., Erden, A.: *Design of a Face Recognition System*. In: 15th International Conference on Machine Design and Production (UMTIK), pp. 1-12 (2012).
[6] Alamri, H., Alshanbari, E., Alotaibi, S., Alghamdi, M.: *Face Recognition and Gender Detection Using SIFT Feature Extraction, LBPH, and SVM.* Engineering, Technology & Applied Science Research 12(2), 8296–8299 (2022).
[7] Hassaballah, M., Aly, S.: *Face Recognition: Challenges, Achievements and Future Directions*. IET Computer Vision 9(4), 614–626 (2015).
[8] Kar, N., Debbarma, M. K., Saha, A., Pal, D. R.: *Study of Implementing Automated Attendance System Using Face Recognition Technique*. International Journal of Computer and Communication Engineering 1(2), 100–103 (2012).
[9] Pato, J. N., Millett, L. I.: *Biometric Recognition: Challenges and Opportunities*. Washington, DC, USA: The National Academies Press pp. 182 (2010).
[10] Kelly, M. D.: *Visual Identification of People by Computer*. Ph.D. dissertation, Dept. of Computer Science, Stanford University, Stanford, CA, USA (1970).
[11] Zhang, J., Yan, Y., Lades, M.: *Face Recognition: Eigenface, Elastic Matching, and Neural Nets*. Proceedings of the IEEE 85(9), 1423-1435 (1997).
[12] Chellappa, R., Wilson, C. L., Sirohey, S.: *Human and Machine Recognition of Faces: A Survey.* Proceedings of the IEEE 83(5), 705-741 (1995).
[13] Kortli, Y., Jridi, M., Al Falou, A., Atri, M.: *Face Recognition Systems: A Survey*. Sensors 20(2), 342 (2020).
[14] Said, Y., Barr, M., Ahmed, H. E.: *Design of a Face Recognition System Based on Convolutional Neural Network (CNN)*. Engineering, Technology & Applied Science Research 10(3), 5608–5612 (2020).
[15] Mordor Intelligence: Facial Recognition Market - Growth, Trends, COVID-19 Impact, and Forecasts (2022-2027). https://www.mordor intelligence.com/industry-reports/facial-recognition-market (accessed July 21, 2020).
[16] Panchabhaiya, V. (2019): Real-Time Face Detection Using MATLAB. https://www.electronicsforu.com/electronics-projects/software-projects-ideas/real-time-face-detection-using-matlab (accessed July 2020).
[17] Duchaine B., Yovel, G.: *Face Recognition: in The Senses: A Comprehensive Reference*. Elsevier 2, 329-357 (2008).
[18] Vishwakarma, V. P., Goel, T.: *An Efficient Hybrid DWT-Fuzzy Filter in DCT Domain Based Illumination Normalization for Face Recognition.* Multimedia Tools Application 78(11), 15213-15233 (2019).
[19] AT&T Database of Faces: ORL Face Database. http://camorl.co.uk/facedatabase.html (accessed July 21, 2020).
[20] Lowe, D. G.: *Distinctive Image Features from Scale-Invariant Keypoints*. International Journal of Computer Vision 60(2), 91-110 (2004).
[21] Diyasa, G. S. M., Fauzi, A., Idhom, M., Setiawan, A.: *Multi-face Recognition for the Detection of Prisoners in Jail using a Modified Cascade Classifier and CNN*. Journal of Physics: Conference Series 1844, 012005 (2021).