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Face Recognition-Based Automatic Attendance System in a Smart Classroom

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Abstract
The smart classroom is a fully automated classroom where repetitive tasks, including attendance registration, are automatically performed. Due to recent advances in artificial intelligence, traditional attendance registration methods have become challenging. These methods require significant time and effort to complete the process. Therefore, researchers have sought alternative ways to accomplish attendance registration. These methods include identification cards, radio frequency, or biometric systems. However, all of these methods have faced challenges in safety, accuracy, effort, time, and cost. The development of digital image processing techniques, specifically face recognition technology, has enabled automated attendance registration. Face recognition technology is considered the most suitable for this process due to its ability to recognize multiple faces simultaneously. This study developed an integrated attendance registration system based on the YOLOv7 algorithm, which extracts features and recognizes students' faces using a specially collected database of 31 students from Mustansiriyah University. A comparative study was conducted by applying the YOLOv7 algorithm, a machine learning algorithm, and a combined machine learning and deep learning algorithm. The proposed method achieved an accuracy of up to 100%. A comparison with previous studies demonstrated that the proposed method is promising and reliable for automating attendance registration.

Keywords
Attendance, Face recognition, HOG, LBPH, MySQL, YOLOv7.

I. Introduction

AI has significantly increased, leading to a growing desire for automation in various fields. An area where automation is particularly sought after is attendance registration in universities and government institutions. Lecturers and administrative staff are anxious to streamline this time-consuming task [1]. For example, when using traditional methods, such as the paper-and-pen system, marking attendance during a one-hour lecture requires at least ten minutes. This system involves the lecturer recording the date and time on a paper and passing it to students, who write their names. However, this approach has several drawbacks. Firstly, students may become distracted during lectures while focusing on their attendance. Moreover, there is a potential for fraud when a present student marks the attendance of an absent student by impersonating [2]. A similar issue arises with the attendance list system, where the administrative staff provides the lecturer with student names to mark attendance. This method not only consumes a significant amount of lecture time, but also proves bothersome for students and lecturers. Mistakes can occur when students fail to hear their names being called, leading to frustration for all parties involved. Additionally, relying on paper attendance systems poses security risks, as records can easily be lost or stolen [3].

In addition, the process of determining the attendance status of a particular student on a specific date is labor-intensive, involving extensive searching through numerous documents and archives. These challenges necessitated the development of an alternative method that can ensure safe and efficient attendance registration without human intervention. Biometric systems have emerged as a method, utilizing individuals' fingerprints to record attendance.

This study uses a facial recognition-based attendance record system. Facial recognition, a form of artificial intelligence, involves the ability of a computer to identify individuals [4]. With the widespread availability of cameras, facial recognition can now be performed at a minimal cost. The facial recognition process consists of two main steps. First, the system detects human faces in an image or video by extracting them and enclosing them in bounding boxes [5].

Second, the system compares a person's face with faces stored in the database to recognize and verify their identity. Automation of the attendance marking process was crucial to address the issues associated with traditional methods. Several alternative approaches have been introduced to achieve full automation. One such method is the Radio Frequency Identification card-based (RFID) attendance registration, which was among the early attempts [6]. However, this method is not suitable for complete automation due to various limitations. Students are required to queue in long queues to scan their ID cards, which increases the registration time. Moreover, the RFID system poses risks, as cards can be easily shared or misplaced, allowing others to register attendance on someone else's behalf. Additionally, the production and acquisition of cards and reader devices incur significant costs. Given these challenges, researchers have focused on developing alternative automated attendance systems.

Thanks to the technological advancements and the progress of artificial intelligence, researchers have developed innovative solutions to tackle the challenge of attendance registration. One of such solutions is the use of biometric systems that leverage unique human characteristics, such as fingerprints [7]. Fingerprint-based attendance registration systems offer improved accuracy and security compared to RFID, but still face limitations in terms of time and cost. Similarly, iris recognition-based attendance systems encounter similar constraints [8].

In this context, face recognition algorithms have emerged as a groundbreaking approach to automate attendance marking, as no other system could efficiently and accurately handle this task [9]. Face recognition algorithms have revolutionized the automation of attendance processes, especially in scenarios where multiple individuals need to be simultaneously recognized. These algorithms perform two key functions: detecting human faces within an image and differentiating them from other faces in the database. Both of these functions are accomplished using distinct algorithms that have been harnessed to automate the attendance registration process.

Y. W. M. Yusof et al. proposed an automated attendance system that incorporates the Viola-Jones algorithm for face detection and three facial recognition algorithms (Eigenfaces, Fisherfaces and LBPH) [10]. However, the system's limitations should be noted. Firstly, it was only tested on individual students, raising concerns about its performance when applied to a group of students in a classroom setting. Additionally, the registration process requires online completion, which may pose difficulties in areas with limited internet access, particularly in developing countries.

Y. P. Jia et al utilized the Scale Invariant Feature Transform Technique (SIFT) for facial authentication as a complement to the RFID system, employing a facial verification system built on microcontrollers like Raspberry Pi to enhance security [11]. The accuracy achieved was %84, with improved accuracy corresponding to an increase in the number of training images. However, the use of Raspberry Pi adds to the system's cost, and facial recognition performance declines when faces become smaller, such as when individuals sit farther away from the camera. Hence, the distance between the face and the camera becomes a crucial factor influencing the system performance.

M. Jahangir used the ORB algorithm (Oriented FAST and Rotated BRIEF) for facial recognition in his attendance system [12]. The proposed system offers valuable functionality for organizations, although it only tests students individually.

D. Sunaryono aimed to develop an electronic attendance registration system based on Android phones, using facial recognition technology [13]. Logistic regression achieved a high accuracy of approximately 95.21%. Nonetheless, limitations arise from countries with limited internet access and the associated costs of using Raspberry Pi. Furthermore, the system was only tested on individual students.

V. Wati developed an automated attendance system using Gabor wavelets [14]. The system detects faces using the Viola-Jones algorithm, extracts facial features through Gabor wavelets, and performs template matching by comparing the features with those stored in the dataset. The strength of this approach lies in creating the database with individuals displaying various facial expressions while wearing glasses and hats, thereby enhancing system robustness. The study reported an accuracy rate of 88%, a recall rate of 75%, and a precision rate of 97%.

T. Li utilized the MTCNN face detection algorithm, while employing VGG19 for face recognition, resulting in favorable accuracy [15].

N. T. Son et al generated their own dataset with the participation of 120 students across five classes in FPT Polytechnic College building. They employed Facenet and Arcface algorithms for face recognition, achieving an accuracy of 92% [16].

Another approach that can be utilized for attendance systems is the HOG method, as described by R. Tamilkodi [17, 18]. This method achieves an accuracy of 97% by using HOG for feature extraction and KNN for classification. Comparatively, PCA and LBPH achieve accuracies of 91% and 89%, respectively.

F. Majeed et al. developed an automatic attendance system with a remarkable accuracy of 93% by employing YOLOv5 for face detection and recognition [19].

N. A. Ismail et al. adopted a single-stage detector (SSD) for face detection and utilized a ResNet-34-like architecture for feature extraction and classification. Their approach involved storing student information in a MongoDB database. However, this method lacks simultaneous testing of the algorithm with multiple individuals [20].

This study introduces a highly accurate automated attendance registration system that combines LBPH, HOG, and YOLOv7 algorithms. These algorithms were trained on CLAHE-enhanced images to ensure a robust face recognition system. The system was tested in a classroom environment with challenging conditions, including variations in lighting, seating distances, and poses. Remarkably, the proposed system achieved a perfect accuracy rate of 100%. In particular, the system employed the MySQL database management system to minimize costs and did not require additional physical components in addition to the computer and camera.

II. METHODS

Artificial intelligence made it possible to process and recognize biometric characteristics, for example, the face print. There are two types of systems concerning the human face. The first system is the face verification system, which includes extracting the features of the human face and comparing them with the features of the faces stored in the database to identify whether the face under study is the required face or not, i.e., it is an $N \times 1$ comparison system. The result of this type of system is either yes (1) or no (0); that is, it is a two-class classification system. The other type is the human face recognition system, which includes identifying the faces in front of the camera and extracting their features to identify each of the existing faces. It is an $N \times N$ comparison system that compares several faces with all the faces in the database. The result of this system is the identity of the person whose features the algorithm found among the features stored in the database, meaning that it is a multi-class classification system. This study will depend on the use of the facial recognition system because it aims to identify the identities of a group of people at the same moment by fingerprinting their faces. The smart classroom is a classroom in which all operations are automatic, such as opening doors for students to enter or leave, monitoring exams without interference from the lecturer, and recording students' attendance without human intervention. This paper proposes a new method for attendance registration based on a face recognition technique. An Intel(R) Core (TM) i7-7500U CPU @ 2.70GHz 2.90 GHz and 16 GB RAM computer with Windows 10 operating system with Python 3.10 were used to program the system. First, a live stream of the IP camera installed in the classroom is processed using the proposed method to detect faces and extract their features to construct our dataset. Then we trained our system and tested it during lectures. The flowchart of the attendance registration system is depicted in Fig. 1. The system is composed of the following steps.

A. Image enhancement

To ensure a robust face recognition algorithm under various lighting conditions, it is necessary to adjust the illumination of training images, which can be achieved through the use of CLAHE, which has been approved for this purpose. The image is first converted to lab space, and then CLAHE is applied using the following equations [21]:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.41 & 0.35 & 0.18 \\ 0.21 & 0.71 & 0.07 \\ 0.01 & 0.11 & 0.95 \end{bmatrix} \cdot \begin{bmatrix} r'(x,y) \\ g'(x,y) \\ b'(x,y) \end{bmatrix} \tag{1}$$

$$f(r) = \begin{cases} \sqrt[3]{r} & for \quad r > q \\ 7.787r + \frac{16}{116} & for \quad r \leq q \end{cases} \tag{2}$$

$$L = \begin{cases} 116(\frac{y}{y^n})^{-\frac{1}{3}} - 16 & \frac{y}{y^n} > q \\ 903.3\frac{y}{y^n} & \frac{y}{y^n} \leq > q \end{cases} \tag{3}$$

$$a = 500(f(\frac{x}{x^n}) - f(\frac{y}{y^n})) \tag{4}$$

$$b = 200(f(\frac{y}{y^n}) - f(\frac{z}{z^n})) \tag{5}$$

$$L_n = \frac{L - min(L)}{max(L) - min(L)} \tag{6}$$

The best value for q is 0.008856, where L_n is the enhanced lighting channel. The following processes follow the image enhancement process. The image enhancement process is followed by face detection to crop only the faces from the image, reducing the time required for the training process.

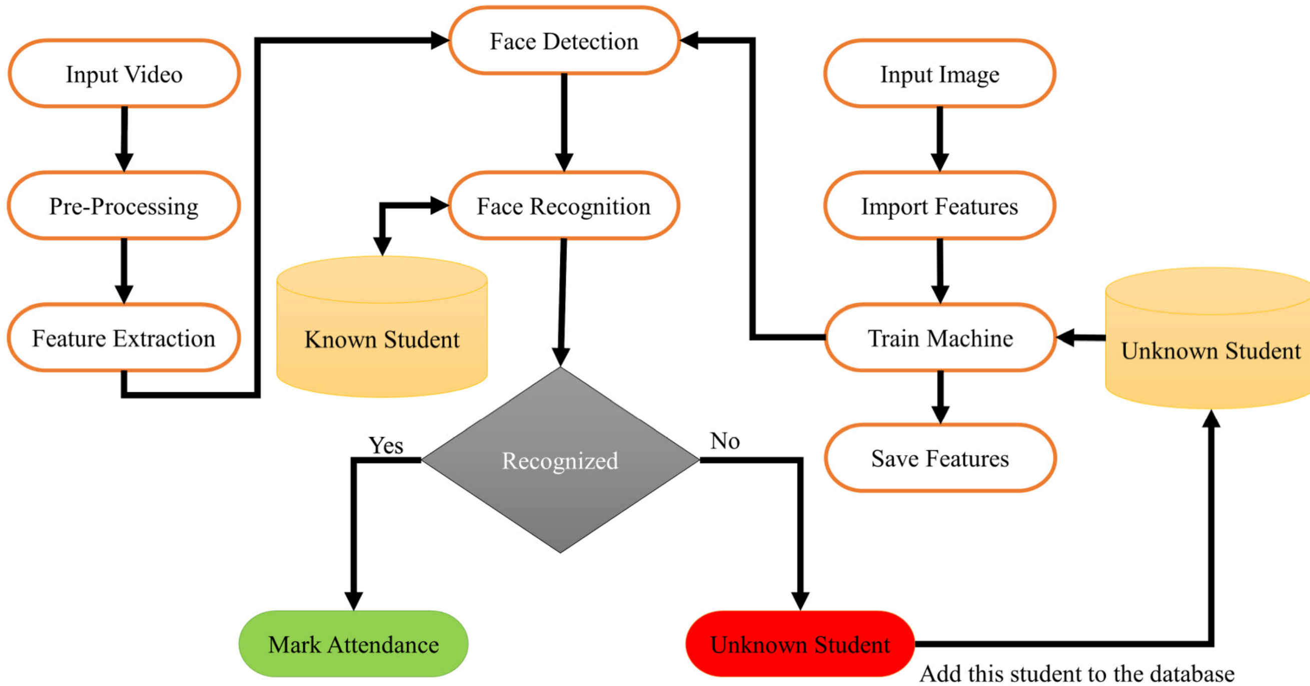


Fig. 1. Flowchart of the system

B. Face detection

It is the procedure of identifying a human face in an image and enclosing it in a box to isolate it from the rest of the image. We utilized three algorithms to accomplish this process. Viola-Jones, HOG, and YOLOv7. The benefit of using face detection algorithms is to speed up the process of real time face recognition. Instead of training the algorithm on full images, we can crop the faces from the images then train the algorithm which improve the quality of the features extraction process and decrease the time required for the training process. These algorithms enclose the face in a bounding box and send the face part of the image onley to the feature extraction algorithms to extract features and compare them with the features stored in the database.

1) Viola Jones algorithm:

This algorithm comprises four steps: the Haar features, integral image, AdaBoost, and cascade classifiers. It was developed by Paul Viola and Michael Jones [22].

2) Histogram of Oriented Gradient (HOG):

This algorithm relies on the horizontal and vertical gradients to decide whether the image contains a face. Eq. (1) & Eq. (2) give the horizontal and vertical gradients, respectively.

$$G_x(r,c) = I(r,c+1) - I(r,c-1) \tag{7}$$

$$G_y(r,c) = I(r-1,c) - I(r+1,c) \tag{8}$$

Then calculate the magnitude (M) and direction of the gradients θ using Eq. (3) & (4)

$$M = \sqrt{G_x^2 + G_y^2} \tag{9}$$

$$\theta = \left|\tan^{-1}\frac{G_x}{G_y}\right| \tag{10}$$

Then perform the following calculations for each value.

$$\Delta\theta = \frac{180}{n} \tag{11}$$

$$C_i = \Delta\theta(i+0.5) \tag{12}$$

$$i = \left[\left(\frac{\theta}{\partial\theta} - \frac{1}{2}\right)\right] \tag{13}$$

$$v_i = M\left(\frac{\theta}{\partial\theta} - \frac{1}{2}\right) \tag{14}$$

$$v_{i+1} = m\left(\frac{\theta - c_i}{\Delta\theta}\right) \quad (15)$$

Where $\Delta\theta$ is the step size of the orientation of the gradient, (n) is the number of bins ranging from 0 to 180 (it can be from 0-360, but the best results were within this range), its value is equal to 9 as the 9-point histogram was used, (C_i) is the value of the center of each bin. After completing the histogram calculations for every block, a $16 \times 8 \times 9$ matrix was produced. After that, it applies L2 normalization to normalize the feature vector to make it less sensitive to lighting variations.

3) YOLOv7:

The YOLO algorithm is the most common single-state object detector in computer vision. It witnessed many developments, from the first version of YOLO, YOLOv1, to the version, YOLOv7. This algorithm acts as a face detector and recognizer based on convolutional neural networks. It consists of 415 layers and has 37358376 parameters to learn. We trained this algorithm for three anchor boxes from scratch on our dataset for 100 epochs. Then, it detects the faces in a real-time stream from the camera installed in the hall and encloses them in bounding boxes. Lastly, using the non-maximum suppression to remove the boxes of less confident. Fig. 2 shows a comparison between YOLOv7 performance and its previous versions. Which shows that this algorithm has the highest average precision among the other versions of YOLO. The authors of YOLOv7 made several changes to the YOLO network and training routines. Among these modifications are the following: 1- Extended Efficient Layer Aggregation 2- Model Scaling Methods 3- Re-parameterization Strategy 4- Coarse to Fine Auxiliary Head

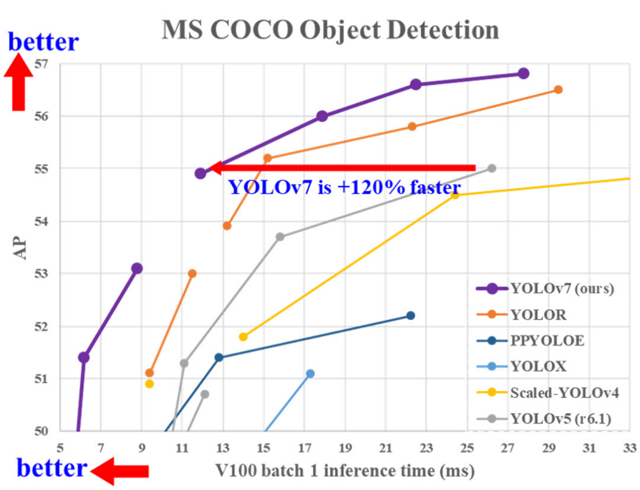


Fig. 2. YOLO versions comparison [23]

C. Feature extraction

The features of the detected face are extracted and stored in a database to compare them with the features extracted from the test images to recognize the given faces. We implement this step using three state-of-the-art algorithms in feature extraction algorithms: LBPH, Dlib's face encoding, and the YOLOv7 algorithm.

D. Dataset preparation

Student information is entered through the input fields in the enrolment window to create a MySQL database. Then, pictures are taken for each student using an IP camera through the Real-Time Streaming Protocol (RTSP). A folder stores the images after they are sent to the face detection algorithm for face cropping. Fig. 3 shows some of the images collected during the study. The students' images were only used in this research paper, with official approval obtained from them. We have collected 2170 images for 31 students, with 70 images for each.

E. Marking Attendance Process

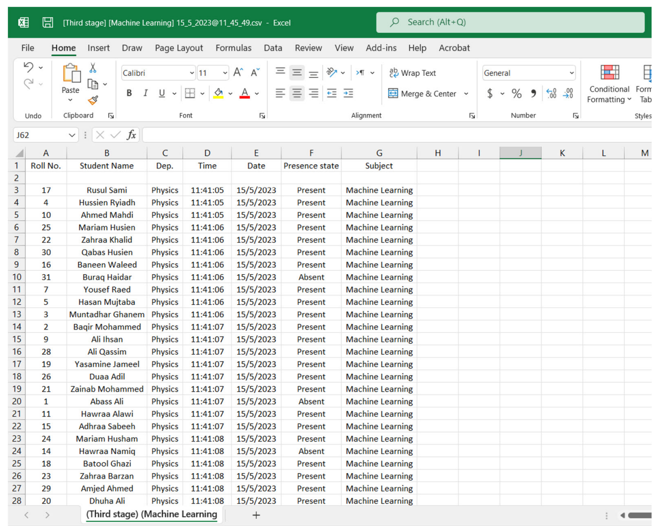
The proposed method in this study is to prepare a database for students by collecting the information of 31 students in the MySQL database. Then take 70 images of each student with different facial expressions and angles from the camera to ensure all the cases the system may encounter during the attendance registration process. Fig. 3 shows a small part of the images prepared for this project. The image acquisition process is done by taking images from the live broadcast of the camera installed inside the classroom using real time streaming protocol (RTSP).

After the image acquisition, the algorithm is trained to distinguish the students' faces using face detection and recognition algorithms. After that, the students are instructed to pay attention to the camera in order to record their presence, and a snapshot from the video is taken (the system user determines the snapshot by clicking on the space button) so that the system processes this video in real time and shows the identities of the students whose faces the system was able to identify. The system determines the student's identity through the name of the folder containing his images. We have previously specified as a number while creating the database to avoid chaos on the computer screen due to the students' full names appearing on it. When the system can identify a student, it automatically accesses the MySQL database, retrieves the student's information, and records it in the csv file, as depicted in Fig.4. If the system cannot determine whether the student is in the database, it will show the phrase "unknown" on the person's bounding box. Then the system saves the csv file with a distinct title as follows:[stage] [subject] date@time.csv Fig. 5 depicts the titles of the generated csv files. The proposed algorithm is depicted by algorithm. 1.

Algorithm 1: The proposed algorithm
Input: A live streaming video from the installed IP camera
Output: csv file of the attendees

```
X, Y → The horizontal and vertical coordinates of the bounding box
W, H → width and height of the bounding box
EF → The extracted features
SF → The stored features of faces in the database
while there is a face in the video:
    predict X, Y, W, H using one of the face detection algorithms
    extract features of the detected faces
    compare EF with SF
    if the features match any of the SFs:
        return the ID of the face
        fetch the ID's information from the MySQL database
        mark attendance of the specific ID in a csv file
    else: Either store the face in the database or show "unknown" on the bounding box
    endif
if (q) key is pressed:
    break
Rename the csv file with the date and time and the subject name
Store the csv file in a specific folder
```

Fig. 3. Portion of the dataset



Roll No.	Student Name	Dep.	Time	Date	Presence state	Subject
17	Rusul Sami	Physics	11:41:05	15/5/2023	Present	Machine Learning
4	Hussien Ryiadh	Physics	11:41:05	15/5/2023	Present	Machine Learning
10	Ahmed Mahdi	Physics	11:41:05	15/5/2023	Present	Machine Learning
25	Mariam Husien	Physics	11:41:06	15/5/2023	Present	Machine Learning
22	Zahraa Khalid	Physics	11:41:06	15/5/2023	Present	Machine Learning
30	Qabas Husien	Physics	11:41:06	15/5/2023	Present	Machine Learning
16	Baneen Waleed	Physics	11:41:06	15/5/2023	Present	Machine Learning
31	Buraq Haidar	Physics	11:41:06	15/5/2023	Absent	Machine Learning
7	Yousef Raed	Physics	11:41:06	15/5/2023	Present	Machine Learning
5	Hasan Mujtaba	Physics	11:41:06	15/5/2023	Present	Machine Learning
3	Muntadhar Ghanem	Physics	11:41:06	15/5/2023	Present	Machine Learning
2	Baqir Mohammed	Physics	11:41:07	15/5/2023	Present	Machine Learning
9	Ali Ihsan	Physics	11:41:07	15/5/2023	Present	Machine Learning
28	Ali Qassim	Physics	11:41:07	15/5/2023	Present	Machine Learning
19	Yasamine Jameel	Physics	11:41:07	15/5/2023	Present	Machine Learning
26	Duaa Adil	Physics	11:41:07	15/5/2023	Present	Machine Learning
21	Zainab Mohammed	Physics	11:41:07	15/5/2023	Present	Machine Learning
1	Abass Ali	Physics	11:41:07	15/5/2023	Absent	Machine Learning
11	Hawraa Alawi	Physics	11:41:07	15/5/2023	Present	Machine Learning
15	Adhraa Sabeeh	Physics	11:41:07	15/5/2023	Present	Machine Learning
24	Mariam Husham	Physics	11:41:08	15/5/2023	Present	Machine Learning
14	Hawraa Namiq	Physics	11:41:08	15/5/2023	Absent	Machine Learning
18	Batool Ghazi	Physics	11:41:08	15/5/2023	Present	Machine Learning
23	Zahraa Barzan	Physics	11:41:08	15/5/2023	Present	Machine Learning
29	Amjed Ahmed	Physics	11:41:08	15/5/2023	Present	Machine Learning
20	Dhuha Ali	Physics	11:41:08	15/5/2023	Present	Machine Learning

Fig. 4. Attendance report

F. Quality Analysis

Before discussing the metrics used in this work, the following parameters must be clarified.

The True positive (TP) is a student whom the algorithm correctly identifies.

A false positive (FP) is a student the algorithm incorrectly identifies as someone else.

We calculated the following metrics to evaluate our work and compare it with that of others:

$$Accuracy = \frac{TP+TN}{TP+FP+TN+FN} \times 100 \tag{16}$$

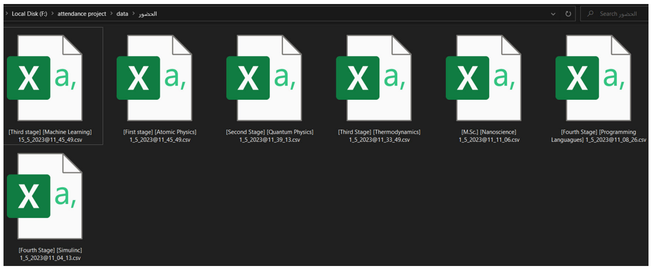


Fig. 5. Title of the generated csv files

$$Recall = \frac{TP}{TP + FN} \tag{17}$$

$$Precision = \frac{TP}{TP + FP} \tag{18}$$

$$F1 - Score = 2 \times \frac{Precision \times Recall}{Precision + Recall} \times 100 \tag{19}$$

A true negative (TN) is a student not in the database but whose identity can be identified by the algorithm as an "unknown person."

False negatives (FN) are students whose faces the algorithm cannot recognize or who are marked as unknown despite being in the database. We calculated the following metrics to evaluate our work and compare it with that of others.

III. Results and Discussion

This study used three methods to train and test the algorithm. All three methods were trained on the 2170 images collected from the students. We processed a live broadcast of the camera installed inside the classroom for testing purposes. The training took place on images of the students individually, while the test was done on a video showing 31 students registered in the database while sitting in the classroom. In other words, training images are entirely different from test images. In addition to the students, the video shows the lecturer standing at the end of the class, and the purpose of its presence is to prove the strength of the method used in detecting faces, in addition to distinguishing whether they are in the database or not, and not using the identity of random people on people who are not registered in the database. It means that it can be applied to universities and schools with precision.

The first method uses the YOLOv7 algorithm to identify and classify faces. The best results were achieved using this technique, as shown in TABLE I. According to Fig. 6, the F1-score curve shows consistently high scores across different thresholds, indicating that the model is reliable and can maintain precision and recall at their peak. These results are where we notice that the algorithm was able to distinguish the faces of the students in an exact manner and without any error. Instead, this algorithm could identify the lecturer's face and recognize that it does not exist within the database on which it was trained. In this method, we reached an accuracy of %100, as shown by the confusion matrix in Fig.7. Fig. 8 shows the change in accuracy and loss during the training process over the 100 epochs. The performance of this method in the classroom can be obtained from Fig. 9. While the second method relied on the use of a combination of the HOG algorithm in addition to the Dlib library in Python to accomplish the process of identifying faces and recording their presence, through Fig. 10, we can note the accuracy of this method, which reaches %94, as shown in TABLE I. This method is characterized by a high degree of precision, reaching %100, as it only shows the student's identity if it is highly certain. For this reason, this method can be applied to automate the attendance registration process accurately. In contrast to the third method, which relied on a combination of the Viola-Jones algorithm and the local binary pattern histogram (LBPH) to identify and distinguish faces, the third method mistakenly gave two students identities different from their real identities. When we found the student with ID No. 12 on the left, her identity was mispredicted, as her real identity is 23, in addition to the lecturer standing at the end of the class. This method could not distinguish that he was not in the database, as shown in Fig. 11.

By observing Table I, we can note that the first method achieved the best results because it relied on deep learning techniques to identify and distinguish faces. The second method relied on the HOG algorithm to recognize faces, which is one of the machine learning algorithms and also relied on the Dlib library, a Python library for deep learning algorithms. This method relied on machine learning to detect faces and deep learning to recognizing them, which caused the technique to be unable to recognize faces of two students sitting at the end of the right row of Fig. 10, so the algorithm could not recognize them. As for the third method, which is based on the Viola-Jones algorithm for detecting faces and LBPH to recognizing them, meaning that this method is entirely dependent on machine learning, it failed to identify the face of one of the female students sitting in the right row of Fig. 11, as well as misclassified one of the female students. It also gave an identity to the lecturer, who the algorithm did not train on his images, and thus this method is considered low-accuracy. The reason behind the low accuracy of the methods based on machine learning is that these methods need to be more balanced during training due to the large amount of data entered into the algorithm. That is why relying on deep learning algorithms was necessary to create a high-accuracy electronic attendance system. Compared with previous studies, the proposed method has achieved promising results in automating the attendance registration process for 31 students in real time and simultaneously, as shown in TABLE II.

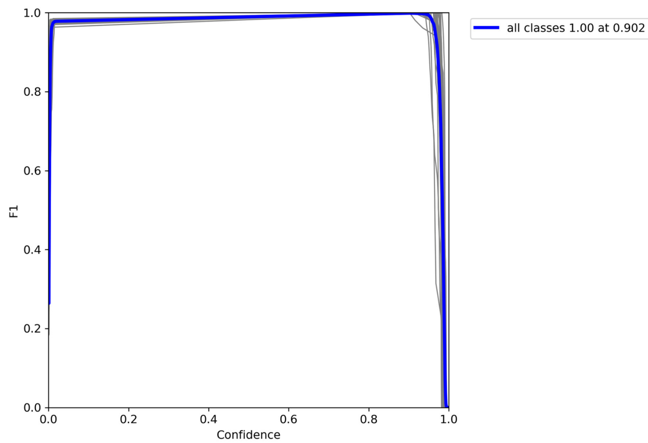


Fig. 6. The F1-curve of our method

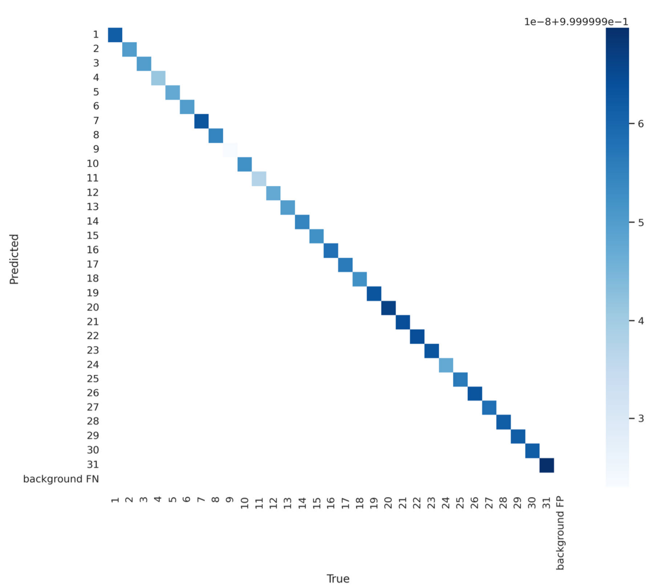


Fig. 7. The confusion matrix of our method

IV. Conclusion

An automated attendance recording system was developed in this study based on a deep neural network using YOLOv7, which is a very effective architecture for accomplishing the real-time attendance process. The proposed method is considered promising in completing the attendance registration process by comparing it with the traditional methods used in previous studies, such as LBP and HOG. We reached 100% accuracy based on our database consisting of 2,170 images with the participation of 31 students from Mustansiriyah University.

The same system was also established using the traditional methods used in previous studies to compare its results with the results of this study. Our proposed method had a much better performance than the traditional methods. Also, the system designed in this study was compared with the systems proposed in previous studies. Our system was superior to the rest of the systems in many parameters, where the number of students registered to attend simultaneously reached 31, regardless of the lecturer that the system could distinguish as not registered in the database. In comparison, previous studies depended on a small group of students. In addition, the proposed method creates attendance reports with distinguished names that people can refer to easily. Regarding deep neural networks, surveillance systems that employ these neural networks will outperform those that do not. If used appropriately and in the right style, deep neural network-based techniques and computer vision-based applications have much to add.

The challenges of this work lie in the difficulty of its implementation in adverse environmental conditions, such as disparate lighting and the accessories used by the students, which hinder the view of their faces by the camera. However, these factors are certainly at their best in the classroom. Secondly, the proposed system takes much time to train the data, but the training process requires that it be done when adding new images to the database. It does not need to be done every time the attendance registration process is executed. In addition, the time required to process the video in real time depends on the computer's specifications. In general, the time required to complete the attendance recording process requires only a few seconds to capture a video of students during the lecture and two to three minutes to process the captured video and record attendance according to the computer used in this study. Also, one of the limitations of this study is its reliance on a small number of images in the database, which is to benefit from the results of this study to design a database that competes with the standard databases in the field of face recognition.

In the future, we are considering eliminating the loopholes mentioned above in the proposed system. We also intend to use the proposed system in various environmental conditions by improving the structure of the model used in this study soon. We also intend to increase the number of images collected in the database with different facial expressions and lighting conditions in order to be a database ready to compete with other databases and apply the system to this database for the commercial use of the proposed system.

TABLE I.
TP, TN, FP, AND FN FOR VARIOUS METHODS USED IN THIS PAPER

Technique	Test Time	TP	TN	FP	FN	Accuracy	Recall	Precision	F1-Score
YOLOv7	5 FPS	31	1	0	0	100%	100%	100%	100%
HOG + Dlib	4 FPS	29	1	0	2	94%	94%	100%	97%
Viola-Jones +LBPH	16 FPS	29	0	2	1	91%	97%	94%	96%

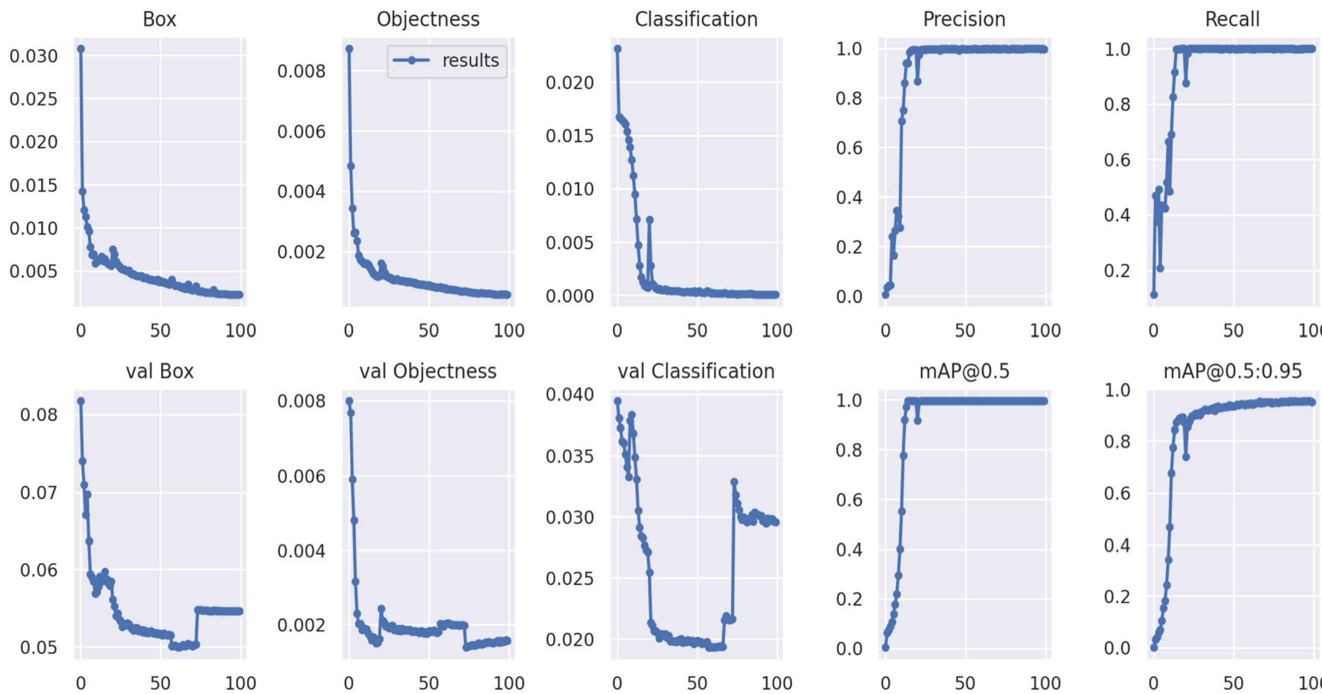


Fig. 8. Multiple metrics of our training process

Fig. 9. YOLOv7 performance in lecture


Fig. 10. HOG performance in a lecture

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

TABLE II.
COMPARISON OF THE PROPOSED METHOD WITH STATE-OF-THE-ART METHODS

Ref.	Method	Year	No. of examined faces	Accuracy
[24]	Viola-Jones + LBPH	2020	6	100%
[15]	MTCNN + VGG19	2021	25	80-90%
[14]	Viola-Jones + Gabor wavelets	2021	5	88%
[25]	PCA + SOM	2022	Lacks real-time implementation	94%
[26]	Viola-Jones + LBPH	2023	1	94%
The Proposed Methods	Viola-Jones +LBPH HOG + Dlib YOLOv7	2023	32	91% 94% 100%

Fig. 11. LBPH performance in a lecture

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