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Research Article

Rapid Marking Attendance with Face Recognition

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Abstract

Marking attendance (MA) of students in the classroom and exam halls is not only a burdensome task for the instructors, but it is also time consuming. There is a growing need for efficient and autonomous techniques in MA. This article introduces an attendance system based on face recognition. The developed method detects the students exploiting their faces present in live camera images or in a given image through the Eigen Face Recognizer algorithm. After then, students are recognized and their attendance information recorded in an offline database. HAAR algorithm is used as a classifier in recognition process. In the experimental studies, it has been observed that the face recognition system works with an average accuracy of 79.31% in the real classroom environment. The obtained results showed that the designed system is promising for automatic authentication and marking attendance in classroom and exam sessions. It has been also shown that with the proposed system, marking, authentication and recording works can be completed in a much shorter time and with higher accuracy.

Keywords: attendance marking, classroom, face recognition, haar classifier, eigenfaces.

Yüz Tanıma ile Hızlı Yoklama Alma

Öz

Öğrencilerin sınıf ve sınav salonlarında yoklamalarını almak (YA), eğitmenler için sadece külfetli bir iş değil, aynı zamanda zaman alıcıdır. YA'da verimli ve otonom tekniklere artan bir ihtiyaç vardır. Bu makale, yüz tanımaya dayalı bir yoklama sistemini tanıtmaktadır. Geliştirilen yöntem, öğrencilerin canlı kamera görüntülerinde veya belirli bir görüntüde bulunan yüzlerini Eigen Face Recognizer algoritması ile tespit etmektedir. Yüzlerinden tespit edilen öğrencilerin yoklama bilgisi bir veri tabanına kaydedilir. Tanıma sürecinde sınıflandırıcı olarak HAAR algoritması kullanılmıştır. Deneysel çalışmalarda yüz tanıma sisteminin gerçek sınıf ortamında ortalama %79.31 doğrulukla çalıştığı gözlenmiştir. Elde edilen sonuçlar, tasarlanan sistemin, sınıf ve sınav oturumlarında otomatik kimlik doğrulama ve yoklama almada umut verici olduğunu göstermiştir. Önerilen sistem ile işaretleme, doğrulama ve kayıt işlemlerinin çok daha kısa sürede ve daha yüksek doğrulukla tamamlanabileceği de gösterilmiştir.

Anahtar Kelimeler: *yoklama alma, sınıf, yüz tanıma, haar sınıflandırıcı, eigenfaces*.

1. Introduction

Ensuring students' attendance and attendance is an important issue for their success (NAYIR, 2017). For this purpose, various rules about absenteeism and certain absenteeism limits have been determined in each educational institution. The implementation of these rules naturally imposes an additional burden on the teaching staff in addition to the educational activities. For this purpose, attendance lists are used in the classrooms or teaching environment. Either the instructor reads the names of the students from the attendance list and puts a sign for the current student, or the attendance sheet is passed across classroom so that students can sign.

Sometimes, another student may forge a signature on behalf of the proper student. In fact, encountering more signatures than the actual number of students in the class is one of the problems faced by instructors. In order to avoid such problems, instructors have to check the number of students participating with the number of signatures. Even if the number of signatures are found correct, someone else can be in the class on behalf of a student taking the course. Identities should be checked in order to determine the participation of someone unrelated to the course. As can be seen, in order to prevent fake participation, the entire class must pass an identity check. This causes wastage of course time, which is very valuable for instructors and the classroom.

The issues mentioned above are also valid for exam sessions or various activities. Especially in exams, it is often seen that the student taking the exam is replaced by another student or a non-student. Therefore, identity checks in exam sessions are more stringent, making it very tedious and time consuming for both parties.

With the development of technology, various systems such as biometric methods and image-based identification systems have been developed for various purposes (Yalçın & Gürbüz, 2015). Iris recognition for use in areas such as security control, identity control (Vyas, Kanumurı, Sheoran, & Dubey, 2019), fingerprint recognition (Radzı, Hanı, & Bakhterı, 2016), and face recognition (FR) techniques are used (Çetinel, Çerkezi, Yazar, & Eroğlu, 2016). Biometrical techniques are detailed in Figure 1 (Patel & Priya, 2014).

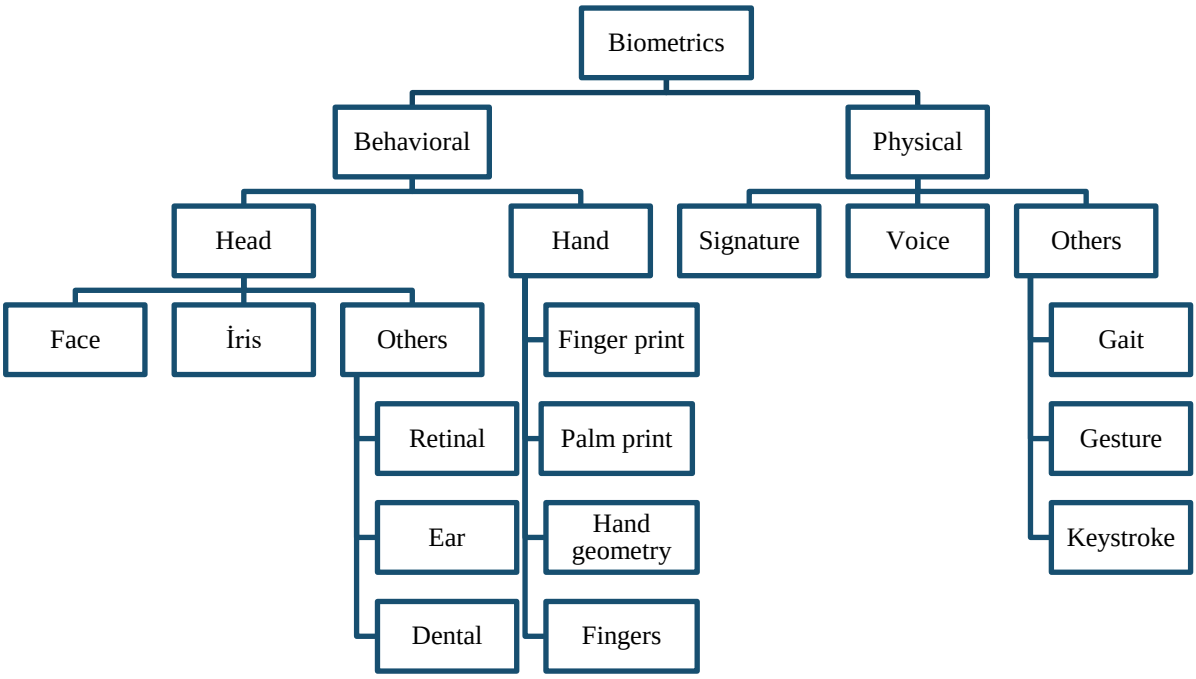

Figure 1 Biometric Techniques Used for Identification (Patel and S. Priya, 2014).

In this study, a student attendance system based on face recognition with HAAR classifier is designed. For the identification process, the Eigen Value Face Recognition (EVFR), which is exploiting the Principal Component Analysis (PCA) algorithm, is used. The identities of the students were tried to be determined through the images obtained in the real classroom environment. It has been seen that the designed system works with 79.31% accuracy. The designed system is promising to be used for authentication and attendance at classroom and exam sessions.

This paper continues as follows. In the second part, relevant studies and trends are discussed. The third section explains the proposed method in detail. The results are presented in section four. Section five discusses various subjects and concerns. Section six outlines the entire work as a conclusion. Some ideas and plans are given in section seven.

1. Related Works

Various methods have been developed for the purposes of monitoring the presence of students in the teaching environment through the instructor, and facilitating their work by González-Agulla et al. (González-Agulla, Alba-Castro, Argones-Rúa, & Anido-Rifón, 2010). Some of these are based on fingerprint reading, some based on RFID technology (Lim, Sim, & Mansor, 2009) and some based on online login. For example, Moodle (Lim et al., 2009) has attempted to automate absence tracking using RFID barcode scanners or using

barcode scanners. By placing barcode readers or RFID readers in the classroom, the students read the barcode tags or RFID tags and follow up on attendance/participation. Some of them are (Qureshi, 2020), (Sezdi & Tüysüz, 2018). In another study, a web-based and RFID technology-based system was developed by Kassim et al. (Kassim, Mazlan, Zaini, & Salleh, 2012). The studies in Özcan et al. (Özcan, Saray, & Mustafa, 2018) and Aydın and Dalkılıç (Aydin & Dalkılıç, 2018) aimed at to introduce mobile devices with RFID. Additionally, Uğuz and Turan (Uğuz & Turan, 2021) and Kumbhar et al. (Kumbhar, Wanjara, Trivedi, Khairatkar, & Sharma, 2014) designed similar attendance tracking system working on Android platform.

Quick Response (QR) code is a 2D barcode that can be read by machines. It is first designed for automotive industry. However, it is very prevalently used today, almost everywhere thanks to mobile phones with digital cameras. QR code is one of technologies used for attendance tracking. Hooi, Kalid and Tachmammedov (Hooi, Kalid, & Tachmammedov, 2018) have developed such a system, whereas Jacksi, Ibrahim and Ali (Jacksi, Ibrahim, & Ali, 2018) combined web technologies with QR code.

There are also new technologies that have just joined our lives that make our lives easier. Such that, Near Field Communication (NFC) technology. It ensures the communication of devices without any physical touch for a short range distances. With the development of this technology, various attendance systems have been developed (Hamzah et al., 2019), (Mohandes, 2017), (Daramola, Folorunsho, Ayogu, & Adewole, 2019), (Chew et al., 2015), (Doewes & others, 2018). There are other systems that combine NFC technology with RFID technology. Kommey, Anyane and Amuzu (Kommey, Anyane-Lah, & Amuzu, 2018) proposed a fingerprint recognition technology working with NFC. Another fingerprint-based study is performed by Zainal et al. in (Zainal, Sidek, Gunawan, Manser, & Kartiwi, 2014). Mane and Tikka (Mane, Tikka, Deshpande, & Toke, 2019) proposed an NFC based attendance system along with a GPS module to track students inside and outside the buildings. There is also open software for similar tasks. E.g., (“BiWebAuth (BWA)”) has proposed a framework introducing JAVA library BioWebAuth (BWA).

FR is much more prevalent technique compared to above mentioned techniques. It is already used in every moment of our lives and everywhere. It is so common that nowadays it is almost impossible to find a cell phone that is not sold with FR feature. The successes achieved in FR and the ubiquity of cameras have also enabled attendance systems to have a wide range of use.

In their study, Shehu and Agni (Lim et al., 2009) use machine learning (ML) techniques and HAAR classifiers to take the visual of the classroom in five-minute periods and perform the FR process. It performs face recognition with the Eigenfaces (Turk & Pentland, 1991) technique, which is known for its fast processing. Only 70% of the faces of total 147 students were detected and only 30% were recognized correctly. Krishnan and Balaji (Krishnan & Balaji, 2015) also used Eigenfaces to detect faces from images that are only taken from the front. In this way, 96.5% and 94% of the students were detected recognized, respectively. As the shooting angle of the images changed, the success rate was considerably decreased. It even went down to 0 for images taken from sides (90°).

Kawaguchi et al. (Kawaguchi, Shoji, Lin, Kakusho, & Minoh, 2005) designed a movable system that is mounted on the wall where the blackboard is located, one of which is fixed on the ceiling and the other students can be seen in the classroom environment. In this system, the camera on the ceiling detects the seats where the students are likely to sit, and the camera on the wall focuses on the place where the occupied seat is located. Next, the student's photographs are taken for FR. This process continues throughout the course session.

Kainz et al., targeted to detect and recognize students as well as detect anomalies (Kainz, Cymbalák, Lamer, & Jakab, 2014). They used hierarchical fragment-based visual object classification method (Bouchard & Triggs, 2005) for FR. They introduced Histograms of Oriented Gradient (HOG) (Dalal & Triggs, 2005) algorithm for classification. HOG vectors are obtained by dividing the image into small overlapping window segments, and these vectors are processed with a linear Support Vector Machine (SVM). Helmi et al. (Helmi, bin Eddy Yusuf, Jamal, & Abdullah, 2019) developed another FR system, named as FRACAS. Yang and Han aimed at to build an attendance system exploiting a real time video processing (Yang & Han, 2020). They achieved %82 of success. Similarly, Kar et al. (Kar, Debbarma, Saha, & Pal, 2012) also proposed a real time system based on FR. Sawhney et al. has used PCA in conjunction with a Convolutional Neural Network (CNN) structure (Sawhney, Kacker, Jain, Singh, & Garg, 2019). Lukas et al. (Lukas, Mitra, Desanti, & Krisnadi, 2016) proposed a FR system introducing Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) to extract features, and then exploited Radial Basis Function (RBF) classification for MA. Bhattacharya et al. (Bhattacharya, Nainala, Das, & Routray, 2018) took into account portable devices for a similar task. Patil and Shukla (Patil & Shukla, 2014) designed a Raspberry Pi system using PCA and Linear Discriminant Analysis (LDA).

2. Proposed System

In this study, presence of students in classroom is determined with the help of a camera. Facial information obtained from given image file or live camera images are stored in a database. Then, the recognition module is trained with entire data. The system exploits the Eigenface method for recognition. This method analyzes the Eigenface [10] vectors and the face images in the database and calculates the Eigenfaces consisting of Eigenvectors. The students' attendance is marked by comparing the faces in the classroom image obtained from the camera with the face information in the database. In the comparison, Eigenface vector of each face image found in the main image is compared with the Eigenfaces recorded in the database. The system, which is ready after the training, tries to recognize the faces in the camera images obtained and to detect the current students.

3.1. Training and Marking

In the first stage of the process, the FR module needs to be trained. For training, the faces of the students are introduced to the module from the frames of live camera videos or a static image file. It is very important that more than one face profile

of a student is introduced to the system from various angles. After accomplishing the training phase, the camera is turned on during the real session in the classroom environment to identify the students. A rectangle is drawn around the faces of the students whose faces are recognized by the program, and the name of the student is shown just above the rectangle. The registration and training procedures are shown in Figure 2, whereas the entire process of marking attendance in Figure 3.

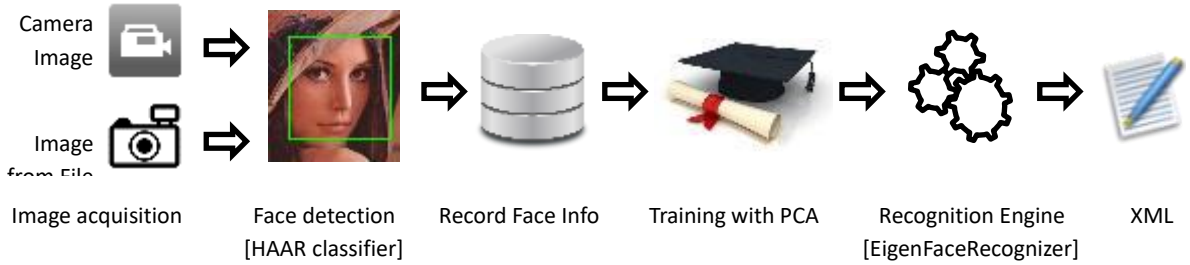

Figure 2. Face Registration and Training.

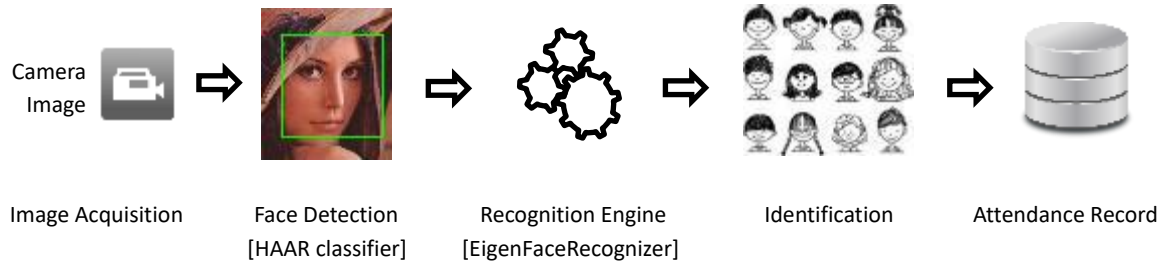

Figure 3. Marking attendance process.

PCA is used for various purposes such as image compression, feature reduction and so on. The face image is first converted to a grayscale. The grayscale image is stored in the database and then training is done after applying PCA. In the training procedure, the EigenFaceRecognizer object which is one of the classes used for face recognition in the OpenCV library, is trained with recorded data. After this process, the FR engine becomes ready. Feature vectors for face data is typically obtained as follows:

1. The mean value of the image is calculated.
2. The covariance matrix is computed.
3. Eigenvectors and Eigenvalues are calculated from the covariance matrix.
4. Eigenvectors are sorted in descending order according to their Eigenvalues and then attributes are obtained.
5. The transform vector is obtained by multiplying the matrix obtained in the first step with the transpose of the feature vector.

The training information obtained from the training procedure is saved in an XML file. This file is of a YAML file format. For later use, the recognition system can be trained quickly by reading this file. Additionally, this training file can be plugged or transferred into another platform or software.

3.2. Software

The main component used in the method is the EMGU library, which is a .NET wrapper developed for the OpenCV (open source computer vision) library. The OpenCV library was developed in Intel's laboratories in Russia to provide open source features such as face recognition, object recognition, and motion tracking in computer vision. On the other hand, the EMGU library provides very easy application development with .NET languages with less code for the OpenCV library written in C++. Microsoft Visual Studio 2015 version was used for code development. An offline Microsoft MSSQL database file (a .mdf file type) was used without server system for recording face information. This offline database allow to transport the information across separate machines.

The main windows of the program is given in Figure 4. Figure shows an image with recognized faces. The program has a single menu containing five subcommands. The subcommands and their tasks are as follows:

Open Camera: works toggle. If the camera is on, the text "Close Camera" is displayed. The user can open or close the camera at any time. In addition, the function of taking images from the camera, which is automatically turned off when it is desired to feed a static image to the program for training or attendance marking purposes, can be reactivated again with this command.

Figure 4. The main window of the program showing recognized faces.

Open Image: Allows a static image file to be fed into the program instead of taking an image from the camera.

Train: Opens the training dialog for training on the active image in the program.

Mark Attendance: opens the attendance marking window for marking students from the image.

Exit: Allows the program to be completely closed.

In the training dialog of the program, there is a text box where the student's name can be entered, a record button to save the active face selected in the image, and navigation buttons for navigating back and forth on the face images in the captured image. The program indicates each detected face with a green rectangle. For each detected face, the name of the predicted individual is written just above the rectangle. It will be appreciated that due to various negative factors and circumstances, not every student can be recognized correctly. “Unknown” is written above the rectangle for such unrecognizable faces.

If the user of the program encounters a misidentified or undetermined face, he or she can save or change the name of the owner of the face by entering the name of the face in the text box by activating that face by clicking the navigation buttons. The frame of the current face is surrounded by a red rectangle in order to show the user which face is being processed while navigating. An example screenshot illustrating this process is given in Figure 5.

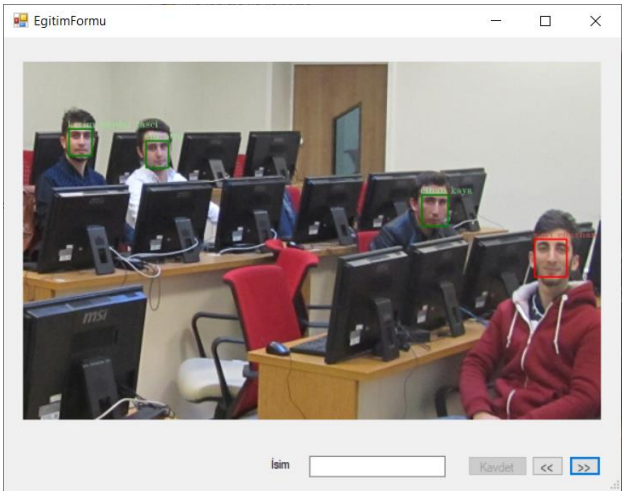

Figure 5. Retraining the program for students who have been identified incorrectly

The MA process quite similar to the training process. For each face, the predicted people's names are shown as done on the trainingscreen. The identity information of the owner of the face that is thought to be matched with the wrong person can also be re-entered on the attendance marking screen. A sample screen output is shown in Figure 7.

After confirming that all the faces are matched with the correct individuals, by clicking the "Take Attendance" button, the people whose faces are detected are registered for the specified course in the database with its id for that session. In the relevant table in the database table, attendance is recorded by assigning a value of 1 for the student's presence and 0 for their absence.

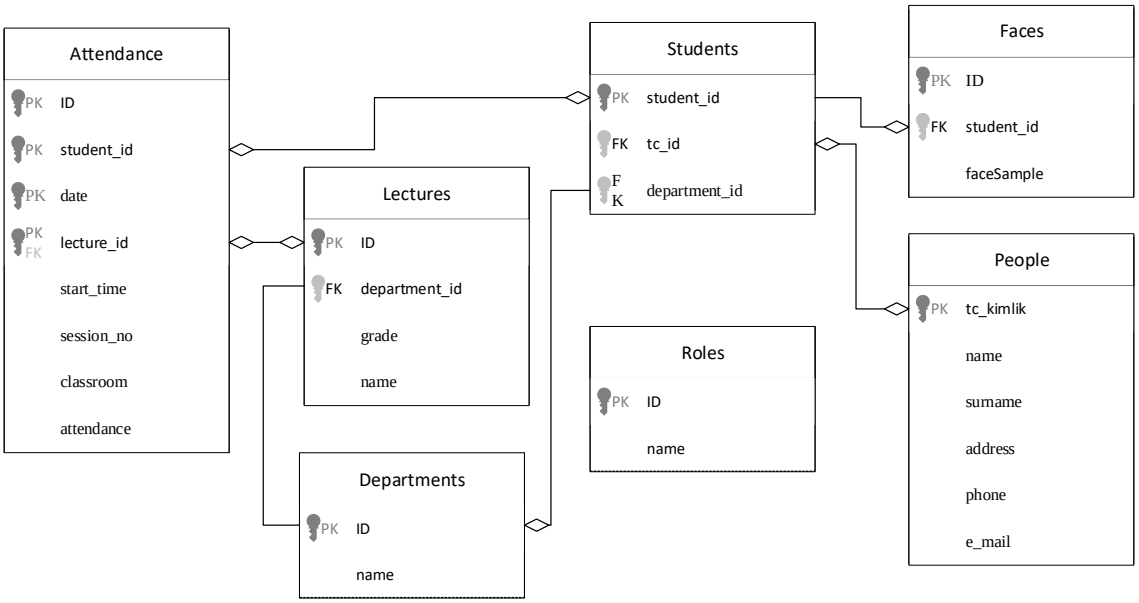

Figure 6. Database schema for marking attendance.

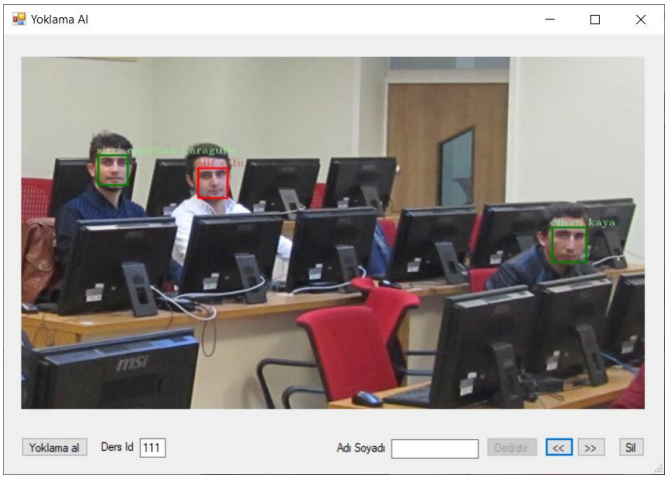

Figure 7. Marking attendance dialog.

3.3. Database

The entire schema of the database is given in Figure 6. Please note that only core and most relevant parts are shown. The rest of the schema is omitted for the sake of simplicity and clarity. The face information is recorded in the table Faces. This table consists of three columns. The column names are as follows: ID, faceSample, and student_id. I describe below the purpose of these columns:

Id: Primary key column retained to ensure each row is unique from the others.

faceSample: Stores the face images of students. Face data is stored as raw binary. A visualized samples of some face images are shown below in Figure 8.

Figure 8. Sample raw images recorded in the database.

Student_id : Holds the id of students. Used to identify the student to whom the face data belongs to when recording multiple face images of a student.

4. Results

In the test procedure, 5 to 10 images of 21 students obtained from various angles were recorded in the database, and then the recognition engine was trained. The training file is saved in an XML file. Images of the real session were taken with a video camera (webcam) in the real classroom environment and it was examined to what extent the identities of the students were determined. Attendance information is registered in the database. When the lecturer marks the attendances for present students, the information for lecture, students, session number, date and class is recorded in the relevant tables of the database. A snapshot of the database for attendance record for a particular lecture is shown in Figure 9.

Student_ID	name	surname	lecture	date	session	classro	attendance
202101011	Hüseyin	Altı...	Bilgisayar Pro	23.12.2021	1	D107	☑
202101027	Sırrı	Emirh...	Bilgisayar Pro	23.12.2021	1	D107	☐
202101019	Kerim	Başç...	Bilgisayar Pro	23.12.2021	1	D107	☑
202101014	Haydar	Taş...	Bilgisayar Pro	23.12.2021	1	D107	☑
202101007	Yusuf	Özg...	Bilgisayar Pro	23.12.2021	1	D107	☑

Figure 9. A snapshot view from database for a lecture.

With the face recognition technique, the entire MA process was completed in an average of 3 minutes. Normally, this process takes 8-10 minutes on average, depending on the number of students in the class. In this way, the time for MA was shortened about 5 minutes.

The students were asked to look at the camera as the faces turned in other directions during the MA process made it difficult for the MA system to recognize their faces. As a result of the experiments, an average accuracy rate of 79.31% was obtained. Accuracy rate varied depending on the student's face orientations and their distance from the camera. The MA system had a difficulty in recognizing the students sitting far from the camera.

Facing the camera in the recognition of students is an important factor for proper recognition. A camera positioned directly in front of the students achieves much more successful results than a camera that takes images from different angles. The more sideways the camera takes, the harder it is to detect faces correctly. Factors such as the students' faces being turned to the camera during attendance and their faces appearing clearly, and sufficient light level significantly affect the success rate of recognition.

5. Discussion

A couple of subjects are discussed in the following subsections.

5.1. Ethics, Law and Security

FR systems, due to the nature of the work, record the face data of people. Storing biometric information poses ethical and legal concerns or issues. Even if it is done in good faith or serves a good purpose, the law numbered 6698 ("Kişisel Verilerin Korunması Kanunu," n.d.) states as follows:

"Conditions for the processing *of special categories of personal data*

ARTICLE 6- (1) Data regarding the race, ethnic origin, political thought, philosophical belief, religion, sect or other beliefs, disguise and dress, membership to associations, foundations or trade unions, health, sexual life, criminal convictions and security measures. Biometric and genetic data is personal data of special nature.

(2) Processing of sensitive personal data without the explicit consent of the person concerned is prohibited…"

Therefore, it is prohibited to obtain biometric data without the consent of the person. For a biometrics-based attendance system, students' explicit consent should be obtained and the permissions taken should be recorded.

Storing human face data in a database raises the issue of the security of this information. For example, a malicious user who has access to the database or someone who infiltrates the system without permission can steal and misuse this information. In order to avoid such inconveniences, face images can be encrypted or mixed encryption of the data can be provided to prevent the original image from being obtained without a secure decoding algorithm.

5.2. Difficulties in Face Detection

People's faces are not rigid and change shape depending on facial expressions such as smile, surprise, sadness, etc. In addition, people grow beards; some grow a whole beard, some grow a beard as long as possible, or grow a mustache. Mustaches can be in diverse styles. People may cut their beard or mustache or change their style. Some of them wear earrings, helmets, glasses and even all kinds of glasses. In some countries, women also wear veils so that only their eyes can be seen. Some even wears sunglasses while veiled. In such a case, face recognition is not even possible.

Even if people didn't make styles that cover some portion or entire face, wearing glasses, studs, or other accessories, face image taken from various angles is one of the difficulties that would be encountered. So, people are active. They change their location. They bend, get up, turn left and right, and so on. They turn their heads. Therefore, it is often not possible to get the image

of human faces from the just opposite side. If a student is not facing the camera while the image is being taken, face detection becomes very difficult. Even more, after a certain point it is not possible. It is not possible for a camera fixed at one point to see the entire classroom environment from the straight ahead. To get rid of the disadvantages mentioned above, and students be very still and face straight to camera for better MA.

6. Conclusion

In this study, a method was designed to automate procedure of marking students' attendance which is onerous and time-consuming task for instructors. The proposed system relies on face recognition method. The developed program detects the faces of the students in the image using the HAAR classifier. It uses the Eigen Face Recognizer object, which is available in the OpenCV library and uses the Principal Component Analysis algorithm for face recognition, in order to recognize individuals from faces. The attendance information of the identified students is recorded in an offline MSSQL database.

The proposed face recognition system achieved an average success rate of 79.31% in the real classroom environment. It was also examined on a synthetically prepared experimental set. The results revealed that the designed method is promising for automatic authentication and marking attendance in classroom and exam sessions. Furthermore, entire process of marking, authentication and recording works can be accomplished within a much shorter time and with higher accuracy.

7. Future Works

The developed program records the attendance information based on face recognition into an offline database. As the next step, it is planned to use an online database. However, a module for manually registering faces that cannot be detected is also planned to include to the new version.

Newly developed technologies such as NFC or QR code, or deep learning techniques are also among the topics to be studied. Another research topic can be the introducing Fisher classifier in replace of HAAR, or the use of both. In particular, the development of systems in which the mobile or IoT devices are integrated in the process are also among the issues to be investigated.

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