Face Recognition-Based Mobile Automatic Classroom Attendance Management System

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***Abstract*—Classroom attendance check is a contributing factor to student participation and the final success in the courses. Taking attendance by calling out names or passing around an attendance sheet are both time-consuming, and especially the latter is open to easy fraud. As an alternative, RFID, wireless, fingerprint, and iris and face recognition-based methods have been tested and developed for this purpose. Although these methods have some pros, high system installation costs are the main disadvantage. The present paper aims to propose a face recognition-based mobile automatic classroom attendance management system needing no extra equipment. To this end, a filtering system based on Euclidean distances calculated by three face recognition techniques, namely Eigenfaces, Fisherfaces and Local Binary Pattern, has been developed for face recognition. The proposed system includes three different mobile applications for teachers, students, and parents to be installed on their smart phones to manage and perform the real-time attendance-taking process. The proposed system was tested among students at Ankara University, and the results obtained were very satisfactory.**

Keywords—face detection, face recognition, eigenfaces, fisherfaces, local binary pattern, attendance management system, mobile application, accuracy

I. Introduction

Most educational institutions are concerned with students' participation in courses since student participation in the classroom leads to effective learning and increases success rates [1]. Also, a high participation rate in the classroom is a motivating factor for teachers and contributes to a suitable environment for more willing and informative teaching [2]. The most common practice known to increase attendance in a course is taking attendance regularly. There are two common ways to create attendance data. Some teachers prefer to call names and put marks for absence or presence. Other teachers prefer to pass around a paper signing sheet. After gathering the attendance data via either of these two methods, teachers manually enter the data into the existing system. However, those non-technological methods are not efficient ways since they are time-consuming and prone to mistakes/fraud. The present paper aims to propose an attendance-taking process via the existing technological infrastructure with some improvements. A face recognition-based mobile automatic classroom attendance management system has been proposed with a face recognition infrastructure allowing the use of smart mobile devices. In this scope, a filtering system based on Euclidean distances calculated by three face recognition techniques, namely Eigenfaces, Fisherfaces, and Local Binary Pattern (LBP), has been developed for face recognition. The proposed system includes three different applications for teachers, students, and parents to be installed on their smart phones to manage and perform a real-time polling process, data tracking, and reporting. The data is stored in a cloud server and accessible from everywhere at any time. Web services are a popular way of communication for online systems, and RESTful is an optimal example of web services for mobile online systems [3]. In the proposed system, RESTful web services were used for communication among teacher, student, and parent applications and the cloud server. Attendance results are stored in a database and accessible by the teacher, student and parent mobile applications.

The paper is organised as follows. Section II provides a brief literature survey. Section III introduces the proposed system, and section IV follows by implementation and results. The last section gives the main conclusions.

II. Literature Survey

Fingerprint reading systems have high installation costs. Furthermore, only one student at a time can use a portable finger recognition device, which makes it a time-consuming process [4]. In the case of a fixed finger recognition device at the entrance of the classroom, attendance-taking should be done under the teacher's supervision so that students do not leave after the finger recognition, which makes the process time-consuming for both the teacher and the students. In case of RFID card reading systems, attendance-taking is available via the cards distributed to students [5]. In such systems, students may resort to fraudulent methods by reading their friends' cards. Also, if a student forgets his/her card, a non-true absence may be saved in the system. The disadvantage of the classroom scanning systems with Bluetooth or beacon methods is that each student must carry a device. Because the field limit of the Bluetooth Low Energy (BLE) system cannot be determined, students who are not in the classroom at the moment but are within the Bluetooth area limits may appear to be present in the attendance system [6]. There are different methods of classroom attendance monitoring using

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face recognition technology. One of these is a camera placed at the classroom entrance and the students entering the classroom are registered into the system by face recognition [7]. However, in this system students' faces could be recognised, although students can leave the classroom afterwards, and errors can occur in the polling information. Another method is the observation carried out with a camera placed in the classroom and the classroom image taken during the course. In this case, the cameras used in the system need to be changed frequently to keep producing better quality images. Therefore, this system is not very useful and can become costly. In addition to all the aforementioned disadvantages, the most common disadvantage is that all these methods need extra equipment. The proposed system has been developed to address these disadvantages. The main advantages of the proposed system are flexible usage, no equipment costs, no wasted time, and easy accessibility.

III. Proposed System

A. Architecture of the Proposed System

The proposed system's architecture based on mobility and flexibility is shown in Fig.1.

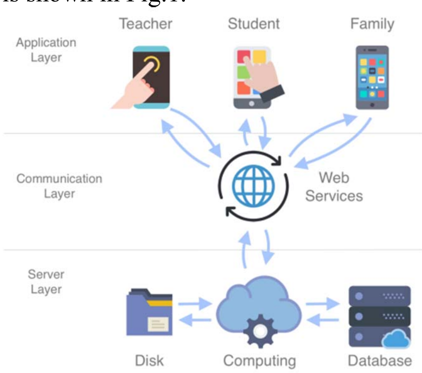

Figure 1. System Architecture

The system consists of three layers: Application Layer, Communication Layer, and Server Layer.

1) Application Layer: In the application layer, there are three mobile applications connected to the cloud server by web services. a) Teacher Application: The teacher is the head of the system, so he/she has the privilege to access all the data. By his/her smart mobile device, he/she can take a photo of students in a classroom at any time. After the taking the photograph, the teacher can use this photo to register attendance. For this aim, the photo is sent to the cloud server for face detection and recognition processing. The results are saved into a database together with all the reachable data. The teacher gets a response by the mobile application and can immediately see the results. The teacher can also create a student profile, add a photo of each student, and add or remove a student to/from their class rosters. He/she can as well create and delete courses. Each course has a unique six-character code. The teacher can share this code with his/her students so they can access their attendance results via the student application. The teacher can access to all data and results based on each student's recognized photo stamped with a date. Additionally, an email message with attendance data of a class in Excel format can be requested, while the analytics of the attendance results is provided in the application. b) Student Application: Students can sign in courses with the teacher's email address and the six-character course code. They can add their photos by taking a photo or a 3-second long video. In case of errors, their uploaded photos can be deleted. Students can only see limited results of the attendance-taking process related to their attendance. To protect personal privacy, the class photos and detected portrait photos of each student can be accessed only by the teacher. If students are not in the classroom when an attendance-check is performed, they are notified of the attendance-check. In case of errors (if a student is present, but not detected by the system), he/she can notify the teacher so he/she can fix the problem. c) Family Application: Parents can see their children's attendance results for each class. Additional children profiles can be added into the system. Each parent is added to the student's application with name, surname, and email address. When a student adds his/her parents, they are automatically able to see the attendance results. They are also notified when their child is not in the classroom.

2) Communication Layer: RESTful web services are used to communicate between the applications and server layers. Requests are sent by the POST method. Each request is sent with a unique ID of the authorised user of the session. Only the authorised users can access and respond the the data to which they have right to access. Due to its flexibility and fast performance, JSON is used as the data format for web services response [8]. With this abstract web service layer, the system can easily be used for a new item in the application layer, such as web pages or a new mobile operating system.

3) Server Layer: The server layer is responsible for handling the requests and sending the results to the client. Face detection and recognition algorithms are performed in this layer and more than 30 different web services are created for handling different requests from mobile applications.

B. Face Detection

Accurate and efficient face detection algorithms improve the accuracy level of the face recognition systems. If a face is not detected correctly, the system will fail its operation, stop processing, and restart. Knowledge-based, feature-based, template-based, and statistics-based methods are used for face detection [9]. Since the classroom photo is taken under the teacher's control, pose variations could be limited to a small range. Viola-Jones face detection method with Ada-boost training is shown as the best choice for real-time class attendance systems [9, 10]. In the most basic sense, the desired objects are firstly found and introduced according to a certain algorithm. Afterwards, they are scanned to find matches with similar shapes [11].

C. Face Recognition

There are two basic classifications of face recognition based on image intensity: feature-based and appearance-based [12]. Feature-based approaches try to represent (approximate) the object as compilations of different features, for example, eyes, nose, chin, etc. In contrast, the appearance-based models only use the appearance captured by different two-dimensional views of the object-of-interest. Feature-based techniques are more time-consuming than appearance-based techniques. The real-time attendance management system requires low computational process time. Therefore, three appearance-based face recognition techniques such as Eigenfaces, Fisherfaces and LBP are used in the tested system. Fisherfaces and eigenfaces techniques have a varying success rate, depending on different challenges, like pose variation, illumination, or facial expression [13]. According to several previous studies, face recognition using LBP method gives very good results regarding speed and discrimination performance as well as in different lighting conditions [14, 15]. Euclidean distance is calculated by finding similarities between images for face recognition. A filtering system based on Euclidean distances calculated by Eigenfaces, Fisherfaces and LBP has been developed for face recognition. According to the developed system, firstly, minimum Euclidean distances of LBP, Fisherfaces and Eigenfaces algorithms are evaluated in defined order. If the Euclidean distance of LBP algorithm is less than 40; else if Euclidean distance of Fisherfaces algorithm is less than 250; else if Euclidean distance of Eigenfaces algorithm is less than 1500, recognized face is recorded as the right match. Secondly, if the calculated Euclidean distances by the three methods are greater than the minimum Euclidean distances, the second level Euclidean distances (40-50 (for LBP), 250-400 (for Fisherfaces), 1500-1800 (for Eigenfaces)) are evaluated in the same way. If the second level conditions are also not met, the filter returns the wrong match. Thirdly, if any two algorithms give the same match result, the match is recorded correctly. Finally, if no conditions are met, the priority is given to the LBP algorithm and the match is recorded correctly. The system's specific architecture aimed for flexibility, mobility, and low-cost by requiring no extra equipment. At the same time, its objective was to provide access to all users at any time. The system thus offers a real-time attendance management system to all its users.

IV. IMPLEMENTATION AND RESULTS

The following platform was used. The cloud server has a 2.5 GHz with 4-core CPU, 8GB RAM, and 64-bit operating system capacity. Viola-Jones face detection algorithm and Eigenfaces, Fisherfaces and LBP face recognition algorithms were implemented based on OpenCV. Tests were done with both iOS and ANDROID. Forty different attendance monitoring tests were performed in a real classroom, including 11 students, and 264 students' faces were detected. Tables I, II, and III show detection and recognition accuracy of all three different types of tested algorithms related to the Euclidean distance.

TABLE I. ACCURACY RATE OF EIGENFACES ACCORDING TO DISTANCE

Euclidean distance (d)	***True***	***False***	***Accuracy Rate (%)***
$d \leq 1500$	26	4	86.66
$1500 < d \leq 1800$	20	9	68.96
$1800 < d \leq 2100$	15	11	57.69
$2100 < d \leq 2500$	23	18	56.09
$2500 < d \leq 3000$	29	18	61.70
$3000 < d$	28	63	30.76

TABLE II. ACCURACY RATE OF FISHERFACES ACCORDING TO DISTANCE

Euclidean distance (d)	***True***	***False***	***Accuracy Rate (%)***
$d \leq 250$	39	0	100
$250 < d \leq 400$	77	19	80.21
$400 < d \leq 550$	37	19	66.07
$550 < d \leq 700$	17	15	53.13
$700 < d$	15	26	36.59
$d \leq 250$	39	0	100

TABLE III. ACCURACY RATE OF LBP ACCORDING TO DISTANCE

Euclidean distance (d)	***True***	***False***	***Accuracy Rate (%)***
$d \leq 40$	15	0	100
$40 < d \leq 50$	55	10	84.62
$50 < d \leq 60$	82	49	62.60
$60 < d \leq 70$	27	22	55.10
$70 < d$	0	4	0

Priority ordering for 3 algorithms was arranged according to accuracy rate for each interval. In test results, 123, 89, and 85 false recognitions were detected for Eigenfaces, Fisherfaces and LBP, respectively. By the help of the developed filtering system, the number of false recognitions decreased to 65. Out of 40 implemented attendance monitoring tests, 10 were conducted with 1 face photo of each student in database in Step-I, 20 were conducted when the number of face photos increased up to 3 in Step-II, and 10 recognition processes were conducted with more than 3 face photos in database in Step-III. Table IV shows the obtained results.

TABLE IV. MEAN PERCENTAGE ACCURACY RATE

Steps	*True*	*False*	*Accuracy Rate (%)*
Step-I	38	17	69.09
Step-II	94	36	72.31
Step-III	67	12	84.81

The most important limitation of tested attendance monitoring process is decreased success with increasing distance between the camera and students. The results regarding students sitting in front seats are more accurate in comparison to results regarding students sitting in the back. Secondly, the accuracy rates may have decreased due to the blurring caused by vibration while the photo was taken. Thirdly, in some cases one part of the student's face may be covered by another student sitting in front of him/her, which may hamper a successful face recognition process. Since the classroom photos are taken in uncontrolled environments, the illumination and pose could, to a large extent, affect the accuracy rate. The developed filtering system minimizes these effects. To increase accuracy, pose tolerant face recognition approach may also be used [16, 17].

V. CONCLUSIONS

The present paper proposes a flexible and real-time face recognition-based mobile attendance management system. A filtering system based on Euclidean distances calculated by Eigenfaces, Fisherfaces, and LBP has been developed. The proposed system eliminates the cost for extra equipment, minimizes attendance-taking time, and allows users to access the data anytime and anywhere. Smart devices are very user-friendly to perform classroom attendance monitoring. Teachers, students, and parents can use the application without any restrictions and in real-time. Since the internet connection speed has been steadily increasing, high quality, larger images can be sent to the server. In addition, processor capacity of the servers is also increasing on daily basis. With these technological developments, the accuracy rate of the proposed system will also be increased. Face recognition could be further tested by other face recognition techniques, such as Support Vector Machine, Hidden Markov Model, Neural Networks, etc. Additionally, detection and recognition processes could be performed on smart devices once their processor capacity is sufficiently increased.

REFERENCES

[1] L. Stanca, "The Effects of Attendance on Academic Performance:Panel Data Evidence for Introductory Microeconomics," J. Econ. Educ., vol. 37, no. 3, pp. 251–266, 2006.

[2] P.K. Pani and P. Kishore, "Absenteeism and performance in a quantitative module A quantile regression analysis," Journal of Applied Research in Higher Education, vol. 8 no. 3, pp. 376-389, 2016.

[3] U. Thakar, A. Tiwari, and S. Varma, "On Composition of SOAP Based and RESTful Services," IEEE 6th Int. Conference on Advanced Computing (IACC), 2016.

[4] K.P.M. Basheer and C.V. Raghu, "Fingerprint attendance system for classroom needs," Annual IEEE India Conference (INDICON), pp. 433-438, 2012.

[5] S. Konatham, B.S. Chalasani, N. Kulkarni, and T.E. Taeib, "Attendance generating system using RFID and GSM," IEEE Long Island Systems, Applications and Technology Conference (LISAT), 2016.

[6] S. Noguchi, M. Niibori, E. Zhou, and M. Kamada, "Student Attendance Management System with Bluetooth Low Energy Beacon and Android Devices," 18th International Conference on Network-Based Information Systems, pp. 710-713, 2015.

[7] S. Chintalapati and M.V. Raghunadh, "Automated attendance management system based on face recognition algorithms," IEEE Int. Conference on Computational Intelligence and Computing Research, 2013.

[8] G. Wang, "Improving Data Transmission in Web Applications via the Translation between XML and JSON," Third Int. Conference on Communications and Mobile Computing (CMC), pp. 182-185, 2011.

[9] X. Zhu, D. Ren, Z. Jing, L. Yan, and S. Lei, "Comparative Research of the Common Face Detection Methods," 2nd International Conference on Computer Science and Network Technology, pp. 1528-1533, 2012.

[10] V. Gupta and D. Sharma, "A Study of Various Face Detection Methods," International Journal of Advanced Research in Computer and Communication Engineering vol. 3, no. 5, pp.6694-6697, 2014.

[11] P. Viaola and M.J. Jones, "Robust Real-Time Face Detection," International Journal of Computer Vision, vol. 57, no. 2, pp. 137-154, 2004.

[12] L. Masupha, T. Zuva, S. Ngwira, and O. Esan, "Face recognition techniques, their advantages, disadvantages and performance evaluation," Int. Conference on Computing, Communication and Security (ICCCS), 2015.

[13] J. Li, S. Zhou, and C. Shekhar, "A comparison of subspace analysis for face recognition," International Conference on Multimedia and Expo, ICME '03, Proceedings, vol. 3, pp. 121-124, 2003.

[14] T. Ahonen, A. Hadid, and M. Pietikainen, "Face description with Local Binary Patterns," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 28, no. 12, pp. 2037-2041, 2006.

[15] T. Ahonen, A. Hadid, M. Pietikainen, and T . Maenpaa, "Face recognition based on the appearance of local regions," Proceedings of the 17th Int. Conference on Pattern Recognition, vol. 3, pp. 153-156, 2004.

[16] R. Samet, S. Sakhi, and K. B. Baskurt, "An Efficient Pose Tolerant Face Recognition Approach", Transactions on Comput. Science XXVI, LNCS 9550, pp. 161-172, 2016.

[17] R. Samet, G. S. Shokouh, J. Li, "A Novel Pose Tolerant Face Recognition Approach", 2014 International Conference on Cyberworlds, pp. 308-312, 2014.