Intelligent Attendance System with Face Recognition using the Deep Convolutional Neural Network Method

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Abstract. Recording student attendance in lectures can be done in several ways, namely giving initials on the attendance sheet or by the lecturer calling each student and then giving a checkmark on the attendance sheet or attendance recording system. This method is inefficient because it is done repeatedly at every meeting, resulting in reduced lecturing time. Some researchers are trying to develop various ways to overcome this, such as using fingerprints, Internet of Things devices, cards with RFID technology, QR codes, and smartphones. However, these technologies require many devices, and they may be costly. The purpose of this research is to develop an intelligent attendance system with facial recognition technology that can identify many people simultaneously without having to make direct contact using the Deep Convolutional Neural Network method. The system is then tested and analyzed for its accuracy in identifying and recording student attendance. The results of research conducted on 16 students in a lecture show that the system can be used to record student attendance with an accuracy of 81.25% in the condition that the student facing forward, 75.00% in the student condition facing sideways, and 43.75% in the student condition facing down.

1. Introduction

Students' presence in attending lectures is one requirement that students will get the lecture material delivered by lecturers [1]. Students who consistently attend classes have a positive correlation with acquired knowledge [2]. The positive relationship between attendance and the knowledge gained is one reason behind the requirement of students' attendance in face-to-face lectures. Several universities in the world have enforced minimum absenteeism limits to take final exams in every course [3], [4]. This regulation makes universities must prepare the administration of student attendance records to find out the percentage of attendance of each student.

The recording of lecture attendance is initially carried out by giving initials on the attendance sheet or by the lecturer calling each student and then giving a checkmark on the attendance list sheet [5]. New technologies facilitate the use and development of attendance mechanism initially from printed papers to an online system. The online attendance system enables attendance data to be stored safely and to calculate the attendance percentage.
Yogyakarta State University (UNY) is one of the various universities that has used online students' attendance. The lecturer carries out recording attendance by accessing the online lecture attendance website so that it no longer uses paper and makes recapitulation easier. Even though it makes recapitulation easier, the current online presence is still inefficient because the recording process is still done manually. To find out students' presence is still done by the lecturer calling the name of each student. This method is inefficient because it is done repeatedly at every meeting, resulting in reduced time used for lectures [6].

Several researchers have developed various methods to overcome this, such as using fingerprints, Internet of Things devices, cards with RFID technology, QR Code, and smartphones [7], [8]. The technology used in this research still has weaknesses. Fingerprint attendance requires a fingerprint reader, which, of course, has a high cost if used in all classrooms. IoT devices and cards with RFID require every student to have a card with RFID and require an RFID reader in every classroom. The use of QR codes and smartphones for attendance depends on smartphone specifications, which, of course, differ for each student.

Technological developments, especially in artificial intelligence and computer vision in facial recognition, create new solutions to detect someone's presence. Facial recognition technology is a safe system and is difficult to fake because the face is also a biometric sign, so it varies from person to person. Facial recognition can lively identify many people at once without having to make direct contact [9]. Facial recognition technology has various advantages so that it can be used in an intelligent attendance system. Although it has multiple benefits, facial recognition technology's accuracy still needs to be tested in recognizing faces, primarily if used in attendance systems. The objectives of this research are (1) to develop an intelligent attendance system capable of detecting attendance automatically using facial recognition technology, and (2) to analyze the accuracy of the attendance system with facial recognition technology in automatically detecting students' attendance.

2. Literature Review

2.1. Face Recognition

The face is a part of the human body as the focus of attention in social interactions, and it plays a vital role by showing identity and emotions. The human ability to identify someone by their face is extraordinary. We can recognize thousands of faces because of the frequency of interactions that are very frequent or only briefly, even over a very long time. We can recognize someone even though there is a change in that person due to increasing age or wearing glasses, or changing hairstyles. Therefore, the face is used as an organ of the human body to allow someone's recognition by means of face recognition [10].

Figure 1. Face identification process diagram

2.2. Convolutional Neural Network

Convolutional neural network (CNN) is deformation inspired multi-layer perceptron by biological vision and surgery preprocessing in their most simplified forms. It is essentially a neural network feeder attacker. The biggest difference between convolutional neural networks and multilayer perceptron is on the network. The first few layers consist of convolutional layers and a pooled layer alternately flows to
simulate a simple cascade of cells and complex cells for high-level feature extraction in the visual cortex [10].

![Convolutional neural network (CNN) algorithm structure](image)

**Figure 2.** Convolutional neural network (CNN) algorithm structure

### 2.3. Deep Learning

Deep learning is one method of Machine Learning using artificial neural networks (ANNs), which is inspired by the structure of neurons located in the human brain [11]. Informally, this word supports the existence of multiple layers in an artificial neural network, but the definition of deep learning has changed over time. Recently, the deep learning technique has demonstrated outstanding capabilities in many areas, such as image classification, speech recognition, and time series prediction [12]. The significant improvement yielding the state-of-the-art achieved for decades was due to the availability of more data and the availability of relatively inexpensive GPUs for highly efficient numerical computations. Under these conditions, research on network design is a very important part of engineering in deep learning. In addition, various studies have been initiated to investigate the potential of CNN (Convolutional Neural Network) and its variations for coding EEG signals, including motor image classification, evaluation of driving fatigue, and recognition of emotions.

### 3. Research Methods

#### 3.1. Materials and Instruments of the Study

The study used various tools in the form of hardware and software such as operating systems, software library, development kit, and database management system. It used a MacBook Pro laptop with 2.3 GHz Intel Core i5 processors, 8 GB RAM with Mac OS Catalina 10.15.6 operating systems, Python 3, PHP 7.4, Visual Studio Code, and MySQL DBMS. The materials used in this study were D4 Electronics Engineering students during the Computer Programming Practices course which was conducted online with Google Meet. Data collection was carried out in online lectures because there was no face-to-face offline class due to the Covid-19 pandemic.

#### 3.2. System architecture

The system to be developed works in several stages, namely 1) Students enter the class to attend lectures; 2) Lecturers open a smart attendance system; 3) The lecturer chooses a class according to the schedule in the system; 4) The lecturer takes class photos from the attendance system; 5) The system works to analyse photos; 6) The system automatically detects the students' presence from the photo using facial recognition. In the form of a diagram, the system work process can be seen in Figure 3. Stage 1) flows from left to stage 2), 3), et cetera until stage 6) following the direction of the arrow.
Figure 3. The process of running the system

The system to be developed is a web-based system consisting of several parts, namely front-end and back-end. The front-end is the view Graphical User Interface (GUI) is the front part of the system that directly interacts with the user. The front-end is developed with JavaScript, CSS, and HTML programming languages. Meanwhile, the back-end is the primary system that carries out the system's functionality, runs algorithms, stores data, processes, and processes data displayed on the front-end. The back-end is developed with Python and PHP programming languages. The back-end has several supports to run the system, namely, services, datasets, and algorithms. The parts of the system can be drawn on the diagram Figure 4.

Figure 4. System architecture

3.3. Face Recognition Algorithm
The facial recognition system requires various stages and algorithms to be able to find facial equations from the training data and real data. Training data is student photo data taken from the system http://presensikuliah.uny.ac.id, while real data are photos taken by lecturers when lectures take place through the system for attendance. There are four algorithms with the main algorithm, namely Deep Convolutional Neural Network, which is used so that the system can recognize faces.

1. Face search algorithm by Histogram of Oriented Gradients (HOG) method [13].
2. Face projection algorithm with Face Landmark Estimation method [14].
3. Face encoding algorithm with Deep Convolutional Neural Network method [15].
4. Algorithm for finding the name of the owner of the face by SVM Classifier method [16].

The algorithm is used sequentially so that the name of the owner of the face can be found from the training data. The stages of using the algorithm can be seen in diagram form Figure 5. From the bottom left of the arrow, the data of class photo were inputted to face search algorithm (HOG), then the next...
process is face projection with face landmark estimation. The result was processed by deep convolutional neural network method (and this method also got training input data). Finally, the name of the photo owner is decided by SVM classifier method in the rightmost box.

![Figure 5. Face recognition algorithm](image)

### 3.4. Data analysis technique

Tests were carried out to determine the facial recognition system's accuracy for automatic presence in various conditions. Each room and student conditions can produce different accuracies, such as students facing the front of all, students facing sideways, or students looking down. To test the accuracy, the instrument used is the one in Table 1.

| No | Conditions                | Grand Total | Number of Accurate Detections | Number of Inaccurate Detections | Percentage of Accuracy |
|----|---------------------------|-------------|-------------------------------|--------------------------------|------------------------|
| 1. | Student facing forward    |             |                               |                                |                        |
| 2. | Student facing sideways   |             |                               |                                |                        |
| 3. | Student face down         |             |                               |                                |                        |

From this instrument, the system's accuracy in detecting presence can be seen so that conclusions can be drawn from these results.

### 4. Results and Discussion

#### 4.1. Intelligent Attendance System

The smart presence system developed has several menus which include various features, namely (1) Students menu; (2) Schedules Menu.

#### 4.1.1. Students menu

This menu is used to manage student data. In this menu, there are various features, namely:
• See the student list
• Add student data
• Edit student data
• Delete student data

When adding and editing student photos, especially student photos, the system will run the CNN algorithm for encoding student faces in a matrix, which is then saved in an .npy file format. This encoding will later be needed to detect students' faces at the time of attendance. Figure 6 is a view of the system that has been developed on the Students menu.

![Figure 6. Display system on the Students menu](image)

4.1.2. Schedules Menu. This menu is used to manage schedules and enter attendance into the system. In this menu, there are various features, namely:

• See a list of lecture schedules that are taught
• Add a class schedule
• Edit class schedules
• Delete class schedule
• Add students or participants to the schedule
• View a list of lecture sessions on a schedule
• Perform attendance at lecture sessions
• View attendance at lecture sessions
• Edit attendee attendance at lecture sessions if the system misidentifies faces

When adding attendance, lecturers are asked to take pictures directly or upload class photos. The system will analyze the image to determine student attendance. The algorithm used to match each student's photo is the SVM Classifier. Lecturers can also manually edit attendance in anticipation whenever the system misidentifies attendance. Figure 7, Figure 8, and Figure 9 are system view on the Schedules menu.
4.2. System Accuracy Test

Testing for the system's accuracy in detecting student attendance was carried out on 16 students of the D4 Electronics Engineering study program who took the Computer Programming Practice course at the time of conducting online lectures using Google Meet. The test results can be seen in Table 2.
Table 2. System accuracy test results

| No | Conditions          | Grand Total | Number of Accurate Detections | Number of Inaccurate Detections | Percentage of Accuracy |
|----|---------------------|-------------|--------------------------------|---------------------------------|------------------------|
| 1. | Student facing forward | 16          | 13                             | 3                               | 81.25%                 |
| 2. | Student facing sideways | 16          | 12                             | 4                               | 75.00%                 |
| 3. | Student face down    | 16          | 7                              | 9                               | 43.75%                 |

From the results of the system's accuracy test, it was found that the accuracy of the detection of student attendance when the student was facing forward was 81.25%. The accuracy of the detection of student presence when the student is facing sideways is 75.00%, and the detection of the student's presence when the student is facing down is 43.75%.

5. Conclusion

The intelligent attendance system can be built using facial recognition using the Deep Convolutional Neural Network method. The system can work automatically to find out students' presence simultaneously based on photos taken during lectures. Training data to compare pictures of each student can use one image for each student taken from http://presensikuliah.uny.ac.id.

The system accuracy test results show that the accuracy of the system for detecting student attendance is 81.25% if the student faces to the front, 75.00% if the student faces sideways, and 43.75% if the students face down. Based on the system's accuracy test results, the position of the face greatly determines the system's accuracy to detect the students' attendance. The face facing the front or the camera is easier to detect than the side facing and down. The detection system's accuracy is reduced to below 50% when the face is facing down.

Although the system detection accuracy level has reached 81.25%, it needs to be improved again so that the system can detect more accurately in various conditions. The study also has not tested the system's accuracy under different lighting conditions and various camera qualities. So that further research will be focused on improving detection accuracy and testing accuracy under multiple conditions.

References

[1] L. Stanca and M. Bicocca, "The Effects of Attendance on Academic Performance: Panel Data Evidence for Introductory Microeconomics," *Economia*, no. 78, 2004.

[2] M. A. Gottfried, "Evaluating the relationship between student attendance and achievement in urban elementary and middle schools: An instrumental variables approach," *Am. Educ. Res. J.*, vol. 47, no. 2, pp. 434–465, 2010.

[3] L. Zhu, E. Huang, J. Defazio, and S. A. Hook, "Impact of the Stringency of Attendance Policies on Class Attendance/Participation and Course Grades," *J. Scholarsh. Teach. Learn.*, vol. 19, no. 2, pp. 130–140, 2019.

[4] T. Chenneville and C. Jordan, "Impact of attendance policies on course attendance among college students," *J. Scholarsh. Teach. Learn.*, vol. 8, no. 3, pp. 29–35, 2008.

[5] R. Samet, "Face Recognition-Based Mobile Automatic Classroom Attendance Management System," 2017.
[6] S. Bhattacharya, G. S. Nainala, P. Das, and A. Routray, "Smart Attendance Monitoring System (SAMS): A Face Recognition based Attendance System for Classroom Environment," 2018 IEEE 18th Int. Conf. Adv. Learn. Technol., pp. 358–360, 2018.

[7] V. Yadav and G. P. Bhole, "Cloud Based Smart Attendance System for Educational Institutions," Proc. Int. Conf. Mach. Learn. Big Data, Cloud Parallel Comput. Trends, Perspectives Prospect. Com. 2019, pp. 97–102, 2019.

[8] K. Navin, A. Shanthini, and M. B. Mukesh Krishnan, "A mobile based smart attendance system framework for tracking field personals using a novel QR code based technique," Proc. 2017 Int. Conf. Smart Technol. Smart Nation, SmartTechCon 2017, pp. 1540–1543, 2018.

[9] B. K. and S. H. E. Varadharajan, R. Dharani, S. Jeevitha, "Automatic attendance management system using face detection," in 2016 Online International Conference on Green Engineering and Technologies (IC-GET), 2016, pp. 1–3.

[10] Y. Li, "FACE RECOGNITION SYSTEM," pp. 2–4, 2010.

[11] Z. Gao and X. Wang, "Deep Learning," pp. 325–333, 2019.

[12] F. F. Q. Xjui, P. O. B. O. E. Mpx, and A. Gulli, Deep Learning with Keras.

[13] N. Dalal and B. Triggs, "Histograms of oriented gradients for human detection," 2005 IEEE Comput. Soc. Conf. Comput. Vis. pattern Recognit., vol. 1, pp. 886–893, 2005.

[14] V. Kazemi and J. Sullivan, "One Millisecond Face Alignment with an Ensemble of Regression Trees," Proc. IEEE Conf. Comput. Vis. pattern Recognit., pp. 1867–1874, 2014.

[15] S. S. Farfade, M. Saberian, and L. J. Li, "Multi-view face detection using Deep convolutional neural networks," ICMR 2015 - Proc. 2015 ACM Int. Conf. Multimed. Retr., pp. 643–650, 2015.

[16] H. S. Dadi and G. K. Mohan Pillutla, "Improved Face Recognition Rate Using HOG Features and SVM Classifier," IOSR J. Electron. Commun. Eng., vol. 11, no. 04, pp. 34–44, 2016.