Face Recognition Student Attendance using Haar Cascade Algorithm

Nisrina Marwah
School of Computer Science Bina
Nusantara University
Jakarta, Indonesia
nisrinamarwah00@gmail.com

Maylaffinza
School of Computer Science Bina
Nusantara University
Jakarta, Indonesia
maylaffinza@binus.ac.id

Jackson Bhakti Gusman
School of Computer Science Bina
Nusantara University
Jakarta, Indonesia
jackson.gusman@binus.ac.id

David David
School of Computer Science
Bina Nusantara University
Jakarta, Indonesia
david01@binus.edu

Panji Arisaputra
School of Computer Science
Bina Nusantara University
Jakarta, Indonesia
panji.arisaputra@binus.ac.id

***Abstract* — Attendance is a form of arrival data collection that is widely used by people, especially students. However, to do attendance in a large number of students makes it difficult for lecturers to manage it because it takes a lot of time and can cause attendance errors. In this digitalization era where many people have coexisted with technology, Face Recognition is a method that provides solutions to the problem of absenteeism today. Of the various algorithms that have been created and developed, according to our research, the Haar Cascade algorithm and face recognition lib are successful to be one of the attendance systems. Both of the methods have a high rate accuracy for haar cascade is 96.24% and the face recognition model is 99.38%.**

***Keywords* — Face Recognition, Face Detection, Haar Cascade Algorithm, Student Attendance, Cascade Classifier**

I. Introduction

A. Background

The student attendance system is a process used to determine if students are attending classes as required. Attendance tracking is essential in managing and monitoring classroom activities. There are several ways of tracking attendance such as calling out individual names manually, using fingerprints, using cards, and more.

To improve efficiency and speed, new methods are needed to take attendance in the classroom. Computer vision technology could be a new way to take attendance for students in class. With the rapid development of technology, particularly in the field of computer vision, this technology can be deployed in the student attendance system. Using a camera sensor to detect faces when entering the classroom, the Haar Cascade method is used to identify faces in the image implemented in the face detection phase. This method was chosen because of its ability to detect objects in digital images quickly and accurately.

In this paper, the author analyzes the Haar Cascade method and its implementation in the face recognition system. The author also tests and evaluates the performance of the system created using this method. This paper contributes to the field of information technology and provides a solution to improving the efficiency of student attendance management on campus.

B. Problem Statement

Based on the background provided, several problems will be the focus of this academic work, namely:

1. How can the Haar Cascade method be implemented to create a face recognition system for student attendance at Bina Nusantara University?

2. How accurate is the performance of the face recognition system created using the Haar Cascade method to identify student faces and mark their attendance?

3. What are the advantages of using a face recognition system for student attendance on campus compared to traditional attendance methods?

4. What are the challenges faced when implementing the Haar Cascade method for the face recognition system, and how can they be addressed?

5. What factors can affect the performance of the face recognition system, and how can the system's performance be optimized?

This problem statement aims to address several research questions related to the use of the Haar Cascade method for creating a face recognition system for student attendance at Bina Nusantara University. The questions will investigate the accuracy and advantages of this system compared to traditional attendance methods, as well as factors that can affect its performance and possible optimization methods. Additionally, the study will identify possible challenges in implementing the Haar Cascade method and suggest ways to address them.

C. Research Purpose

Based on the stated research questions, several objectives can be identified for this academic work, namely:

1. To implement the Haar Cascade method in developing a face recognition system for student attendance.

2. To evaluate the performance of the face recognition system created using the Haar Cascade method to identify student faces and mark their attendance with a high degree of accuracy.

3. To analyze the benefits of using a face recognition system for student attendance on campus compared to traditional attendance methods, including time efficiency, human resources, and cost.

4. To identify factors that can affect the performance of the face recognition system and provide solutions to optimize the system's functionality, such as image quality, lighting, and system parameter settings.

This research aims to achieve several objectives related to developing a face recognition system for student attendance using the Haar Cascade method. The objectives include evaluating the performance of the system, analyzing its benefits, and optimizing its functionality based on factors that could affect its performance. The study aims to contribute to the development and implementation of a robust and efficient system for student attendance.

II. Literature Review

Attendance management is crucial in educational institutions to track student attendance and identify potential risks of falling behind academically. Regular attendance is essential for student success and chronic absenteeism can negatively impact student learning, resulting in lower academic achievement, increased dropout rates, and decreased engagement in school. Many studies have explored strategies and interventions to improve the quality of study in class.

Face recognition technology has found applications in numerous fields such as public safety, civil economy, and home entertainment [1][2], it also can be used in academic fields especially for attendance systems. Compared to traditional attendance systems, face recognition offers higher accuracy and stability due to multiple recognition points and can be done automatically, continuously, and in real-time using standard image processing equipment. In recent years, significant improvements have been made in the accuracy and congestion issues of the technology [3], making it an attractive option for many applications [4]. The haar cascade method has been shown to achieve over 90% accuracy and is effective for attendance management [5]. The Haar-like algorithm is also effective in recognizing faces in low-resolution images with occlusions [6]. However, Haar-like features may not be accurate in recognizing faces with non-frontal poses. The neural network-based approach studies proposed the accuracy of face recognition, especially for non-frontal poses and challenging lighting conditions [7]. It has been demonstrated that using face recognition for attendance management can improve the quality of study [8]. However, the current classifiers do not detect faces of children accurately, suggesting a need for future improvements [9]. Studies highlight the privacy concerns associated with personal data collection, storage, and usage. Legal and ethical considerations related to data protection regulations and human rights are also crucial to address in these matters [10].

Traditional manual attendance marking, and biometric attendance systems have several limitations, including time-consuming processes and high maintenance costs [11]. Face recognition has become an important field of research in computer vision due to its vast applications in security, surveillance, and various other fields [11], [13], [17], [19]. Therefore, we propose the use of a computerized attendance system that uses face recognition technology to automate the attendance-taking process [12]. The proposed system utilizes the Haar Cascade Algorithm to detect and recognize faces in real-time. The Haar Cascade classifier is used to face detection [15], [16], [17], [18], [20], which are then compared to a predefined database of faces to identify the student. The system architecture of the proposed face recognition-based attendance system comprises three stages: face detection, face recognition, and attendance management. In the face detection stage, the system uses a Haar Cascade Classifier algorithm to detect faces in the input images captured by a camera. The face recognition stage involves training a machine learning model using the Principal Component Analysis (PCA) algorithm to recognize and identify the faces detected in the input images. Finally, in the attendance management stage, the system marks attendance for the recognized faces and stores the attendance data in a database. [15].

The study proves that the Haar Cascade classifier system is a viable option for attendance systems, especially in scenarios where a fast-processing time is essential [16]. Also, the advantages of using a face recognition-based attendance

system, including its potential to save time and reduce errors compared to traditional methods. However, it also acknowledges some of the limitations and challenges, such as the need for high-quality images and the possibility of false positives or negatives [15]. Compared with other face recognition systems that use the Haar cascade classifier and other algorithms such as Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), and Support Vector Machine (SVM), the results show that the Haar cascade classifier achieves higher accuracy than other systems [18]. The system can be further improved by incorporating additional features such as temperature scanning to enhance its functionality [20] or it can be used on larger datasets and in real-world scenarios. [14].

In a study by Kolte [21], a presence system based on facial recognition was developed and tested. The system can accurately identify the students and record their presence using the camera and facial recognition algorithm. Shetty et al. [22] used Haar cascade classification and Local Binary Pattern (LBP) to develop facial recognition systems. The system can detect and recognize faces with 94% accuracy. Bairagi et al. [23] developed a real-time face recognition system using a Haar cascade classifier. The system can recognize faces and identify individuals with high accuracy, even in low-light conditions. Ayubi et al. [24] used the Haar cascade classifier to develop real-time face detection for 2-degree-of-freedom (DOF) robot heads. The system can detect and track human faces in real time. Arfi et al. [25] developed a real-time human face detection and recognition system based on Haar's features. The system can detect and recognize faces accurately even in crowded environments. Teoh et al. [26] used deep learning for face recognition and recognition. The system can accurately recognize faces, even when images are of poor quality or taken from different angles. Salama et al. [27] developed a deep facial recognition system using intelligent computer algorithms. The system can achieve high accuracy in facial recognition even in difficult lighting conditions.

Lu and Yan [28] developed a face detection and recognition algorithm using computer vision sensors. The system was able to detect and recognize faces with high accuracy in real time. Mellouk and Handouzi [29] performed facial emotion recognition assessment using deep learning. The study looked at different strategies and techniques used in deep learning-based facial emotion recognition systems. Rayavel et al. [30] developed a real-time machine learning method for a smart door unlocking system using facial recognition. The system can recognize authorized users and unlock the door in real time.

In summary, facial recognition technology has shown promise for time management systems. Different approaches, including CNN, Haar cascade and LBP classifier, SVM, PCA, LDA, and deep learning, have been explored, each with advantages and limitations. However, concerns about privacy and bias must also be considered when implementing these systems.

III. Methodology

A. Data Collection

The first step is to collect a face database that will be used to run the system. This dataset can be collected by taking pictures of the users who will be using the system. For experiments, we took data of 32 students from Binus Maya LMS website.

B. Pre-Trained Model

The system employs the Haar cascade classifier, a pre-trained model, to detect faces in the input video frames. The OpenCV library in Python is used to implement face detection based on the Haar cascade. For face classification using face recognition model, this model detecting or confirming the identity of individuals based on facial images.

C. System Development

The system will capture users' face images, detect and recognize faces, and mark attendance accordingly. here is the step:

a. Face Encoding: After detecting faces using a haar cascade pre-trained model, the system extracts facial features from the detected regions. The face_recognition library in Python is employed to encode the faces into a numerical representation known as face encodings. These encodings capture unique facial characteristics that enable face recognition.

b. Face Recognition The system compares the generated face encodings with a database of known face encodings. It uses the face_recognition library to compute the similarity between the input face encodings and the known face encodings. The system identifies the best match by calculating the face distance and selecting the minimum value. If the face matches a known face, the system assigns a corresponding name to the recognized face.

c. Attendance Recording When a face is successfully recognized, the system records the attendance by storing the recognized name and the timestamp in a CSV file. The attendance data is organized in a tabular format for easy reporting and analysis.

D. Testing and Evaluation

The last step is to test and evaluate the performance of the system. The authors tested the overall system, based on various metrics such as recognition accuracy, speed, and usability.

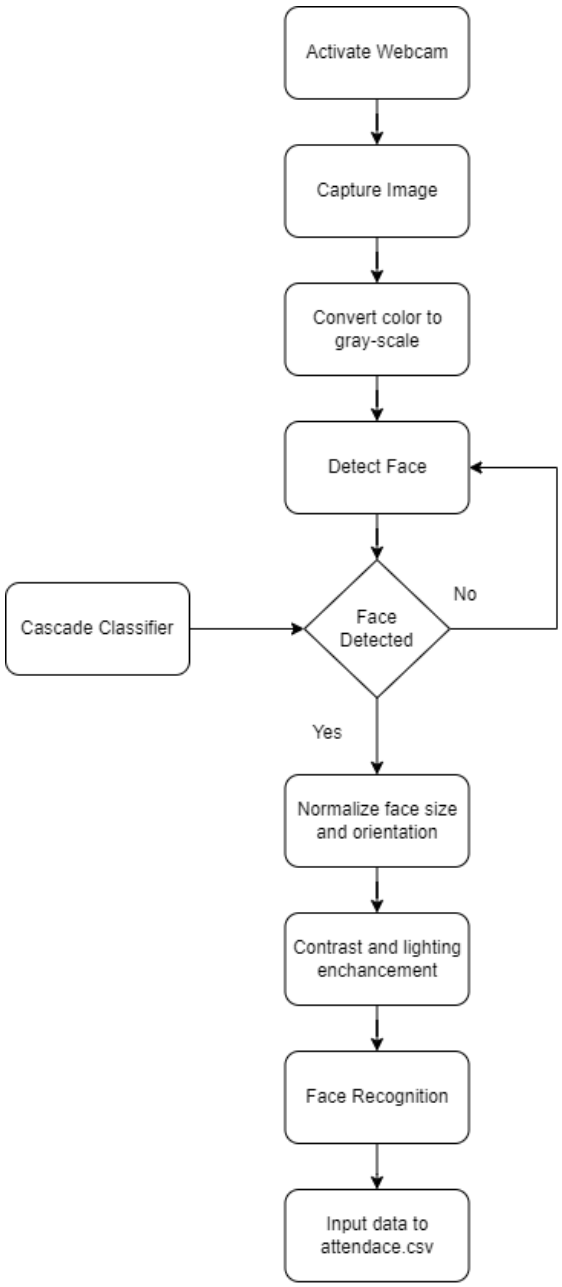

Fig. 1. Haar Cascade flowchart.

Fig. 1. represents the Haar Cascade classifier's flowchart. The image is initially taken by the webcam camera. The image that was acquired is converted from color to grayscale. After the cascade classifier finds the face, it normalizes the size and orientation of the face. The image will next be processed and compared to the dataset of sample faces. Attendance receives the matching detected face that was entered.csv.

IV. Experiments

In this research paper, we present an experiment that utilizes face recognition techniques to detect and recognize faces in real-time using the Haar cascade classifier and face_recognition library. The experiment aims to evaluate the performance and effectiveness of the implemented face recognition system.

A. Experimental Setup:

1. Dataset
   The experiment uses a dataset of known faces stored as images in the "known" directory. Each image corresponds to a unique individual and is labeled with the person's name.

2. Real-time Video Capture
   The experiment captures video frames in real-time using the OpenCV library. The frames are processed to detect and recognize faces

3. Face Detection Algorithm and Recognition
   The experiment utilizes the face_recognition library, which employs the pre-trained Haar cascade classifier for face detection and computes face encodings for recognition.

4. Attendance system
   The detected and recognizable face is going to be input in attendance.csv

B. Experimental Procedure:

1. Initialization: The experiment initializes by loading the known face images from the "known" directory. The face encodings and corresponding names are extracted and stored for later recognition.

2. Face Detection and Recognition: The experiment continuously captures video frames from the webcam. Each frame is processed to detect faces using the Haar cascade classifier and face classification using face_recognition library. Detected faces are then compared with the known face encodings to recognize and label the faces in the frame.

3. Display and Evaluation: The experiment displays the video frames with rectangles around recognized faces and their corresponding names. The experiment continues until the user presses the 'control+c' key to exit.

C. Evaluation:

The authors tested the overall system, based on various metrics such as recognition accuracy, speed, and usability.

1. Face detection.
   The system is able to detect more than one face, but there are still some limits, depending on the distance to the camera. After several tests we can conclude more than one face can be accurately detected at 1.5 m distance from the camera. in condition not wearing a cap or a mask. Sometimes a face can be detected when using glasses, but might be recognized as the wrong person, depending on the brightness of the room. Haar cascade face detection accuracy calculation[9]:

   True positive (TP): the truth is positive, and the test predicts a positive. The correctly classified faces can be calculated as [31]:

   True positives rate (TPR) = TP/(TP+FP)

   False-positives (FP): the truth is negative, but the test predicts a positive.

   False-negatives (FN): the truth is positive, but the test predicts a negative. False negatives rate:

   (FNR)=FN/(FN+TP)

   Accuracy = (TP + TN) ⁄ (TP + TN + FP + FN) (3)

Table 1

Haar Cascade classifier.

No.of faces in an image	Execution Time (sec)	No.of faces detected	Accuracy (%)
5	0.141	5	100
10	0.055	9	90
15	0.11	12	80
20	0.369	19	95

Where,

TP: True Positive FP: False Positive
TN: True Negative FN: False Negative
By using Equation (3) Accuracy is obtained for the Haar cascade is 96.24% [9].

2. Face Recognition.
   The system is able to recognize faces from the known database. The disadvantage of this face recognition system, sometimes one person can be detected as another person, it rapidly changes the output, but mostly the most output given is the correct answer. it tested that the brightness and camera position have a big influence on the output. Built using dlib's state-of-the-art face recognition built with deep learning. The model has an accuracy of 99.38% on the Labeled Faces in the Wild benchmark[32].

3. Attendance system.
   The attendance database system used in these experiments is very simple. There are several limits like erasing the attendance taken. Because the face recognition detected output is rapidly changed, the researchers make the system to do only taking attendance when the face of a known person is recognized for a 5 seconds. So every time a person recognizes a different wrong person the attendance is not taken. Given the face recognition system mostly recognizes the right person this method is effective.

V. Results and Conclusion

The experiment demonstrates real-time face recognition capabilities using the implemented system. The system successfully detects and recognizes faces in the video frames, matching them with known individuals from the dataset.

The experiment showcases the effectiveness of the implemented face recognition system using the Haar cascade classifier and face_recognition library. The results indicate that the system can detect and recognize faces in real-time scenarios. However, it is important to note that the performance of the system is not too good because the recognized face changes rapidly on the same person depending on various factors, such as lighting conditions, pose variations.

Therefore, researchers find the solution for that, because the overall accuracy recognition most of the times is correct, the attendance only taken when the known face is detected for 5 seconds. In this way the attendance system is more effective and does not take too much time.

This system still has limitations because we don't use a proper database system, there is still a lot of room for improvement especially in the data management. and considering this Face Recognition Student Attendance using Haar Cascade Algorithm is easy and quite efficient, this method is effectives for use in the real live application. of course, with a little bit of improvement in the management database system and the algorithm calculation.

Further research and improvements can be made to enhance the system's robustness and accuracy. These may include using more advanced face recognition algorithms, incorporating deep learning techniques, and expanding the training dataset to cover a wider range of individuals and scenarios.

Overall, the experiment provides valuable insights into the practical application of face recognition systems and serves as inspiration for future research in the field of computer vision and biometric identification.

References

[1] F.M. Javed Mehedi Shamrat, Anup Majumder, Probal Roy Antu, Saykot Kumar Barmon, Itisha Nowrin, Rumesh Ranjan, "Human Face Recognition Applying Haar Cascade Classifier" in *International Conference on Pervasive Computing and Social Networking [ICPCSN 2021].,* Salem, Tamil Nadu, India, 19-20, March 2021,pp. 1-4.

[2] C.Stoll, R.Palluel-Germain, R.Caldara, J.Lao, M.W.G.Dye, F.Aptel, and O. Pascalis, "*Face recognition is shaped by the use of sign language*" *J. Deaf Stud. Deaf Educ.*, vol. 23, no. 1, pp. 1–9, 2018.

[3]W.Deng ,J.Hu, J.Guo, "*Face recognition via collaborative representation: Its discriminant nature and superposed representation*" *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 40, no. 10, pp. 2513–2521, Oct. 2018.

[4] S. Chakraborty, S. K. Singh, and P. Chakraborty, "*Local gradient hexa pattern: A descriptor for face recognition and retrieval*" *IEEE Trans. Circuits Syst. Video Technol.*, vol. 28, no. 1, pp. 171–180, Jan. 2018.

[5]T. Q. Vinh and N. T. N. Anh, "*Real-Time Face Mask Detector Using YOLOv3 Algorithm and Haar Cascade Classifier,*" 2020 IEEE Conference on Information and Communication Technology (ICOICT), 2020, pp. 1-5,

[6]A. Adouani, W. M. Ben Henia, and Z. Lachiri, "*Comparison of Haar-like, HOG and LBP approaches for face detection in video sequences,*" in Proceedings of the 16th International Multi-Conference on Systems, Signals & Devices (SSD), 2019, pp. 1-6.

[7]M. Afifi, "*Face detection and recognition using Haar-like features and neural network,*" Egyptian Informatics Journal, vol. 20, no. 1, pp. 55-63, 2019.

[8] Rajeev Yadav, Sumit Chauhan, Meenu, Swati Gupta "*Face Recognition Based on Attendance Management System*" in International Journal of Innovative Research in Computer Science & Technology (IJIRCST), vol. 8, no. 3, pp. 1-10, 2020

[9] Anirudha B. Shetty, Bhoomika, Deeksha Jeevan Rebeiro, Ramyashree, "*Facial recognition using Haar cascade and LBP classifier,*" *Elsevier B.V., KeAi Communications, pp.* 334, 2021.

[10] J. J. Park, J. H. Choi, "*Facial Recognition-Based Attendance Management System: Privacy Concerns and Legal Regulations,*" Journal of Information Processing Systems, vol. 15, no. 6, pp. 1376-1393, 2019.

[11] Tong Bing Ko, Y. Xi, and Y. Yin, "*Face Recognition with Deep Neural Network in Real-World Scenes*" Highlights in Science, Engineering and Technology, vol. 38, pp. 208–214, Mar. 2023, doi: https://doi.org/10.54097/hset.v38i.5807.

[12]P. Contardo et al., "*FRMDB: Face Recognition Using Multiple Points of View*." Sensors, vol. 23, no. 4, p. 1939, Feb. 2023, doi: https://doi.org/10.3390/s23041939.

[13] M. He, "*Studies Advanced in Mask Face Recognition based on Deep Learning*." Highlights in Science, Engineering and Technology, vol. 39, pp. 1196–1202, Apr. 2023, doi: https://doi.org/10.54097/hset.v39i.6728.

[14] Y. Wang, Y. Li, and H. Zou, "*Masked Face Recognition System Based on Attention Mechanism*." Information, vol. 14, no. 2, p. 87, Feb. 2023, doi: https://doi.org/10.3390/info14020087.

[15] N. T. Surajudeen-Bakinde et al., "*Development of Face Recognition Based Attendance System*" SLU Journal of Science and Technology, vol. 6, no. 1 & 2, pp. 214–224, Apr. 2023

[16] S. Malhotra, V. Aggarwal, H. Mangal, P. Nagrath, and R. Jain, "*Comparison between attendance system implemented through haar cascade classifier and face recognition library.*" IOP Conference Series: Materials Science and Engineering, vol. 1022, p. 012045, Jan. 2021, doi: https://doi.org/10.1088/1757-899x/1022/1/012045.

[17] A. H. Ahmad et al., "*Real time face recognition of video surveillance system using haar cascade classifier*." Indonesian Journal of Electrical Engineering and Computer Science, vol. 21, no. 3, p. 1389, Mar. 2021, doi: https://doi.org/10.11591/ijeecs.v21.i3.pp1389-1399.

[18] A. Chakraborty, S. Sharma, "*REAL TIME FACE DETECTION AND RECOGNITION SYSTEM USING HAAR CASCADE CLASSIFIER AND NEURAL NETWORKS*." *INFORMATION TECHNOLOGY IN INDUSTRY*, vol. 9, no. 1, pp. 224–231, Feb. 2021, doi: https://doi.org/10.17762/itii.v9i1.122.

[19] G. S. M. Diyasa, A. Fauzi, M. Idhom, and A. Setiawan, "*Multi-face Recognition for the Detection of Prisoners in Jail using a Modified Cascade Classifier and CNN*." Journal of Physics: Conference Series, vol. 1844, no. 1, p. 012005, Mar. 2021, doi: https://doi.org/10.1088/1742-6596/1844/1/012005.

[20] M. Archana, C. Nitish, and S. Harikumar, "*Real time Face Detection and Optimal Face Mapping for Online Classes*." *Journal of Physics: Conference Series*, vol. 2161, no. 1, p. 012063, Jan. 2022, doi: https://doi.org/10.1088/1742-6596/2161/1/012063.

[21] P. R. R. Kolte, "Students Attendances System Using Face Recognition," International Journal for Research in Applied Science and Engineering Technology, vol. 9, no. 12, pp. 851-856, Dec. 2021, doi: 10.22214/ijraset.2021.39392.

[22] A. B. Shetty, Bhoomika, Deeksha, J. Rebeiro, and Ramyashree, "Facial Recognition using Haar Cascade and LBP Classifiers," *Global Transitions Proceedings*, Aug. 2021, doi: https://doi.org/10.1016/j.gltp.2021.08.044.

[23] R. Bairagi, R. Ahmed, S. N. Tisha, Md. S. Sarder, Md. S. Islam, and Md. A. Islam, *A Real-time Face Recognition Smart Attendance System with Haar Cascade Classifiers*. 2021. doi: 10.1109/icirca51532.2021.9544872.

[24] D. A. A. Ayubi, D. A. Prasetya, and I. Mujahidin, “Pendeteksi Wajah Secara Real Time pada 2 Degree of Freedom (DOF) Kepala Robot Menggunakan Deep Integral Image Cascade,” *Cyclotron*, Feb. 2020, doi: 10.30651/cl.v3i1.4306.

[25] A. M. Arfi, D. Bal, M. K. Hasan, N. Islam, and Y. Arafat, *Real Time Human Face Detection and Recognition Based on Haar Features*. 2020. doi: 10.1109/tensymp50017.2020.9230857.

[26] K. Teoh, R. C. Ismail, S. Naziri, R. Hussin, M. Isa, and M. S. S. M. Basir, “Face Recognition and Identification using Deep Learning Approach,” *Journal of Physics*, vol. 1755, no. 1, p. 012006, Feb. 2021, doi: 10.1088/1742-6596/1755/1/012006.

[27] D. S. Abdelminaam, A. N. D. Almansori, C. E. D. M. Taha, and E. M. Badr, “A deep facial recognition system using computational intelligent algorithms,” *PLOS ONE*, vol. 15, no. 12, p. e0242269, Dec. 2020, doi: 10.1371/journal.pone.0242269.

[28] D. Lu and L.-M. Yan, “Face Detection and Recognition Algorithm in Digital Image Based on Computer Vision Sensor,” *Journal of Sensors*, vol. 2021, pp. 1–16, Sep. 2021, doi: 10.1155/2021/4796768.

[29] W. Mellouk and W. Handouzi, “Facial emotion recognition using deep learning: review and insights,” *Procedia Computer Science*, vol. 175, pp. 689–694, Jan. 2020, doi: 10.1016/j.procs.2020.07.101.

[30] P. Rayavel, A. Sivakumar, P. V. Gopirajan, S. Surenderanath, and P. Rathnavel, “Real time Machine Learning Approach for a Smart Door Unlocking Using Face recognition System,” *IOP Conference Series: Materials Science and Engineering*, vol. 1130, no. 1, p. 012080, Apr. 2021, doi: 10.1088/1757-899x/1130/1/012080.

[31] Sirajdin Olagoke Adeshina, Haidi Ibrahim, Soo siang teoh and seng chun hoo “cus- tom face classification model for classroom using haar-like and lbp features with their performance comparisons”, MDPI 6, Jan 2021.

[32] ageitgey (2022) Face Recognition [Source Code] https://github.com/ageitgey/face_recognition.