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NOVEL FACIAL RECOGNITION AND ATTENDANCE LOGGING: A ROBUST PIPELINE COMBINING DEEP LEARNING AND META-LEARNER

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***Abstract*—The ineffectiveness of conventional approaches has led to a considerable increase in the need for automated attendance management systems in business and educational settings. For precise and effective attendance tracking, this study offers a real-time facial recognition-based system that makes use of transfer learning strategies. For face feature extraction, the system makes use of pre-trained ResNet34 and EfficientNet models, which are then improved via a meta-learner module to improve predictions. Real-time photos are captured using a live webcam interface, which automatically registers attendance by comparing them to a pre-stored dataset. The system also keeps track of entry and exit timestamps, which makes it possible to determine how long each student stays in class. This technology dramatically increases accuracy, scalability, and real-time performance when compared to traditional techniques like Haar Cascade and KNN-based face recognition. The incorporation of transfer learning guarantees flexibility in a variety of scenarios, rendering the system a resilient and expandable attendance solution.**

Index Terms*— *Deep Learning, Face Recognition, Meta-Learner, Transfer Learning, ResNet34, EfficientNet.

I. INTRODUCTION

In many industries, including business settings and educational institutions, managing attendance is essential since it has a direct impact on data dependability and operational effectiveness. Conventional methods, such RFID devices, manual roll calls, and swipe cards, are frequently hampered by human error, inefficiency, and manipulation risks. These systems might also be unable to scale when dealing with big groups, and they might not have the automation and real-time features needed in situations with high demand. Conventional attendance methods are also vulnerable to proxy attendance, which lowers the records' accuracy and dependability.

Facial recognition technology has become a viable answer to the growing need for automated, contactless attendance systems. Facial recognition systems, which use deep learning and computer vision, provide an effective and non-intrusive method of tracking attendance. In the post-pandemic period, when reducing physical contact has become a top concern for safety and hygiene, these approaches are especially pertinent.

We offer a real-time, facial recognition-based attendance system in this project that automates the attendance monitoring process. Using pre-trained ResNet34 and EfficientNet models for facial feature extraction, the system uses transfer learning techniques. To increase recognition accuracy, a meta-learner module is used. Images are taken via a live camera interface, and the system logs attendance records with timestamps and identifies users by comparing their faces to a dataset that has been previously stored. In contrast to conventional systems, our method offers a real-time, scalable, and reliable solution appropriate for a variety of settings.

Under ideal circumstances, the suggested system outperforms the competition, attaining high accuracy and efficiency while overcoming obstacles like ambient influences and dataset unpredictability. The promise of facial recognition technology to automate attendance management is demonstrated in this work, which also establishes the ground work for future developments, such as lightweight model optimization and improved performance in difficult situations like dim lighting and occlusions.

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II. Literature Review

This paper examines the developments in facial recognition systems that use Convolutional Neural Networks (CNNs) for attendance management. The review highlights the greater accuracy of CNN architectures in real-time applications, specifically focusing on ResNet and VGG. Prior studies have concentrated on conventional machine learning techniques like Principal Component Analysis (PCA) and Support Vector Machines (SVM), but these algorithms have trouble handling the considerable diversity in occlusions, lighting, and facial emotions. By automatically learning hierarchical features from facial photos, CNNs have increased their resilience to such obstacles, providing a viable solution for precise attendance monitoring in dynamic contexts, as the paper highlights. [1]. This study proposed a class attendance system utilizing the MTCNN for efficient face detection and the DeepFace framework for face recognition. This hybrid approach ensures robust feature extraction and accurate identification, addressing challenges such as variations in facial features and real-time processing requirements [2]. This paper investigates the use of deep CNNs for face recognition in attendance systems, focusing on robustness against environmental variations such as lighting, pose, and occlusion. The study also discusses ethical concerns and privacy considerations in biometric-based attendance tracking [3].This study examines the use of CNNs, including InceptionV3, for face recognition in smart attendance systems. It highlights how deep learning overcomes the limitations of traditional methods like barcode scanning, offering higher accuracy and automation, which is increasingly being adopted in educational institutions to reduce fraud and improve efficiency [3]. This study surveys face recognition systems built on deep learning, particularly focusing on CNNs for automatic attendance marking. The review covers various approaches, from traditional methods like Haar cascades and KNN to more advanced deep learning methods. It also discusses the application of various CNN architectures, such as AlexNet and MobileNet, and their efficiency in handling real-time image data for accurate face recognition. One key challenge identified in previous studies is dealing with varying lighting and different facial expressions. The authors discuss solutions such as data augmentation and advanced pre-processing techniques that help address these challenges [4]. This study explores the use of transfer learning in facial recognition for attendance management, comparing pre-trained models like VGG16 for feature extraction. Transfer learning reduces the need for large datasets and computational resources, providing more accurate recognition in diverse environments and enabling real-time, scalable applications in large institutions [5]. This survey reviews deep learning techniques for automatic attendance using face recognition, focusing on CNNs, RNNs, and hybrid models. It highlights their ability to adapt to real-world challenges like lighting changes and facial occlusion, while also addressing issues such as computational cost and privacy concerns related to biometric data [6]. This study focuses on the integration of deep learning-based facial recognition for automatic classroom attendance. The review highlights advancements in neural networks, specifically CNNs, and discusses how they improve system accuracy, user convenience, and scalability for large student populations [7]. This study explores the shift from traditional face detection methods to deep learning models like CNNs and GANs for facial recognition in educational institutions. It highlights improved accuracy, handling of varying facial expressions and conditions, and the feasibility of real-time processing on low-cost hardware for large-scale deployment in schools and universities [8].This study delves into the implementation of deep learning for automated attendance in the classroom through facial recognition, applying the use of convolutional neural networks (CNNs) and deep residual networks (ResNet) to maximize precision and speed of student identification. The work reveals the inefficiency of manual techniques and shows the improvement that results from the implementation of these models. The paper also touches on real-world limitations and offers adaptive thresholding and real-time processing of video as solutions [9].This research investigates the use of deep learning for automating classroom attendance through facial recognition with the help of CNNs and ResNet for increased accuracy and efficiency.A different study also emphasizes the usefulness of CNNs and transfer learning in enhancing recognition in changing classroom settings. It overcomes pose variations, illumination variations, and occlusions with sophisticated preprocessing techniques [10].The study investigates deep learning for automatic classroom attendance based on facial recognition, utilizing CNNs and ResNet for precision and efficiency. Another study proposes a smart attendance system based on deep learning using CNNs and VGG-16 for improved facial

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recognition. It incorporates feature extraction and data augmentation methods to enhance precision while overcoming issues such as occlusions and changing lighting conditions. The study proposes an optimized real-time implementation for scalability and efficiency in large institutions [11]. This study suggested transfer learning for facial recognition-based attendance systems, generalizing the model and decreasing dependence on data. The research incorporates pre-trained deep learning models for enhancing recognition in different conditions. The results reveal the effectiveness of transfer learning for optimizing real-time attendance monitoring [12]. A deep hybrid model that unites CNNs and RNNs is proposed to improve the accuracy of facial recognition. Temporal dependencies among facial features are utilized in the research to better identify individuals under changing conditions. The method illustrates higher resistance against pose, illumination, and occlusion variations [13]. A CNN-based attendance system is suggested to automatically recognize faces for student tracking. The research optimizes convolutional layers to enhance face feature extraction and accuracy. The approach facilitates high-speed processing and scalability and is thus adaptable for large-scale institutions [14]. A real-time face recognition system is designed for attendance tracking, combining CNNs with deep learning architectures to improve speed and accuracy. The research aims at minimizing complexity while preserving high recognition performance. The implementation is designed to provide real-time processing appropriate for institutional deployment [15].

III. METHODOLOGY

A. Proposed Undertaking

The proposed system automates attendance marking using real-time facial recognition by integrating a webcam-based interface with deep learning models for accurate and efficient identification. The system continuously captures live video frames, detects faces, extracts deep feature embeddings, and compares them with a pre-stored dataset to recognize students. Once a match is found, the system automatically records attendance along with a timestamp, eliminating the need for manual intervention.

In addition to attendance tracking, the system includes a duration monitoring feature, which logs both entry and exit times for each student. By calculating the total time spent in class, it provides valuable insights into student presence and engagement. This functionality enhances attendance management by ensuring that students are not only present but also remain in class for the required duration.

To achieve high recognition accuracy and robustness, the system employs transfer learning with ResNet34 and EfficientNet for facial feature extraction. These models generate unique facial embeddings, which are refined by a meta-learner module to improve classification accuracy. A Random Forest classifier is also used to validate and assess the extracted embeddings, ensuring the system's reliability in real-world conditions.

By combining real-time image processing, deep learning-based face recognition, and automated attendance logging with duration tracking, the proposed system delivers a scalable, efficient, and intelligent solution for attendance management.

B. Design of the system

The proposed system utilizes pre-trained deep learning models through transfer learning to perform facial recognition with high accuracy and efficiency. The two primary models used for feature extraction are ResNet34 and EfficientNet, which generate deep feature embeddings for each detected face.

ResNet34 is a residual network that addresses the vanishing gradient problem by utilizing skip connections, allowing for deeper feature extraction while maintaining computational efficiency. This model is effective in identifying unique facial characteristics, making it well-suited for face recognition tasks.

EfficientNet is an optimized deep learning model that balances network depth, width, and resolution, achieving state-of-the-art accuracy with fewer computational resources. By using a compound scaling approach, EfficientNet improves feature extraction, enhancing recognition performance even under challenging conditions such as varying lighting and facial expressions.

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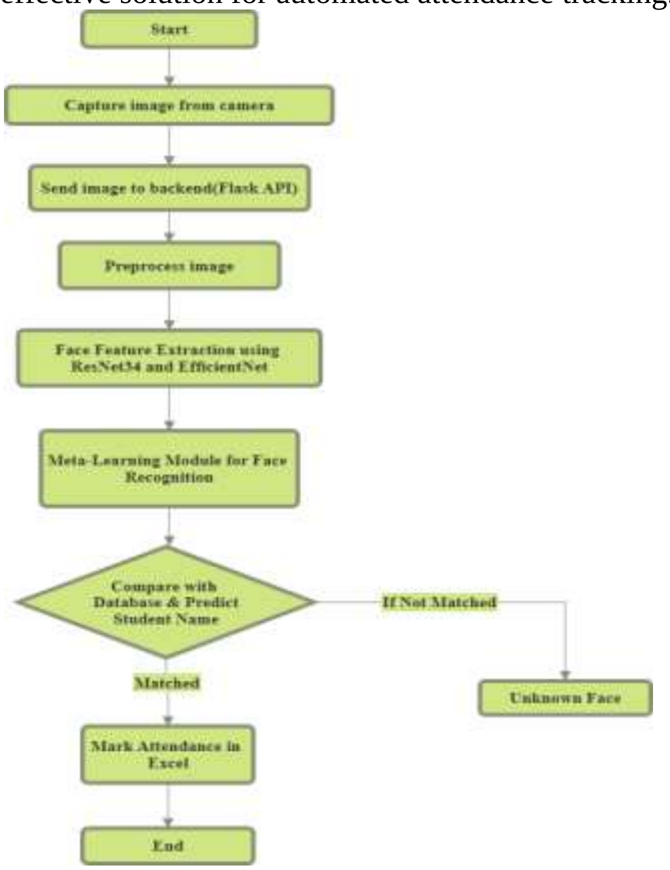
To further refine classification accuracy, a meta-learner module is integrated into the system. This module adjusts decision boundaries dynamically, improving recognition performance by learning from misclassifications. Additionally, a Random Forest classifier is used to validate and assess the extracted feature embeddings, ensuring the reliability of the recognition process.

By combining transfer learning, deep feature extraction, and classification refinement, the system achieves high recognition accuracy, real-time efficiency, and robust performance, making it an effective solution for automated attendance tracking.



IV. Implementation

1. Modules

A. Importing libraries

The project makes use of a number of crucial libraries for data handling, web development, image processing, and deep learning. ResNet34 and EfficientNet models are implemented and optimized using PyTorch (torch, torchvision). Image processing is aided by OpenCV (cv2), while array manipulation is done with numpy. Flask makes it easier for the backend API to handle requests for picture input and recognition. Base64-encoded images from the frontend are processed using io and base64. Datetime logs timestamps, and Pandas (pd) logs attendance data into an Excel sheet. OS also facilitates file management, and logging guarantees effective debugging and API request tracking.

B. Data Collection

The dataset contains images of students, with each student having multiple images captured under different facial expressions, angles, and lighting conditions. The images are organized into classes, where each class represents an individual student. This structured dataset enables the system to extract unique facial features for accurate recognition and attendance recording.

C. Data PreProcessing

By scaling photos to 224×224 pixels, leveling pixel values, and using augmentation techniques including rotation, brightness modifications, and horizontal flipping, data preprocessing improves the accuracy of facial recognition. Furthermore, feature representation is optimized using dimensionality reduction techniques like PCA and t-SNE, guaranteeing strong and trustworthy identification.

D. Model Integration

Using transfer learning, the ResNet34 and EfficientNet models are deployed to extract facial features accurately. A meta-learner module is implemented to enhance recognition performance and improve classification accuracy.

E. Model Training and Evaluation

The model was trained on a well-organized dataset with preprocessing methods such as normalization, resizing, and data augmentation to improve generalization. Feature extraction was done using ResNet34 and EfficientNet, with a meta-learning method fine-tuning the embeddings for better classification. Training was done by optimizing with cross-entropy loss and the Adam optimizer to balance accuracy and computational cost. The evaluation was performed with usual performance measures, and the efficiency of the hybrid model in real-time face identification for attendance management was proved.

F. Attendance Visualization and Reporting

Display the student's name and attendance status along with the facial recognition results in real time on the front end. Capturing and storing attendance data in a database or Excel sheet with timestamps and duration. Generating reports that contain arrival and leave times in order to analyze student participation and attendance.

G. Web Application development

The web application development in this project is handled using Flask for the backend and React for the frontend. React is used for the front end and Flask for the back end of this project's web application development. As the server, Flask takes in image data from the frontend, processes it, and then sends back the recognition results. Images from the webcam are captured by the React-built frontend and sent to the backend through API queries. The student's identity is predicted by the backend after processing the received photos and loading the trained ResNet34 and EfficientNet models. The name and timestamp of the identified student are then saved in an Excel file by the system to record attendance. Efficient communication between the frontend and backend is ensured by implementing proper error handling and reporting.

2. Algorithms

ResNet34

A deep convolutional neural network called ResNet34 (Residual Network with 34 layers) is well-known for its residual learning architecture, which solves the vanishing gradient issue in deep networks. By learning hierarchical representations of facial features, it makes feature extraction more efficient. ResNet34 improves recognition accuracy in this system by producing high-quality facial embeddings.

EfficientNet

A family of convolutional neural network known as EfficientNet was developed to achieve the optimal performance at the minimum possible cost of computing. It is suitable for real-time face recognition applications since it efficiently scales network depth, width and resolution. The system employs the model to enhance recognition accuracy without compromising efficiency, making it ideal for application in real-world applications.

Meta-Learner

The main models (ResNet34 and EfficientNet) produce predictions that are improved by the meta-learner module. It serves as an extra learning layer that analyzes incorrect classifications and modifies the decision bounds to increase classification accuracy. The system is guaranteed to adjust to changes in occlusions, lighting, and facial expressions thanks to this module.

Transfer Learning

Transfer learning makes use of pre-trained deep learning models which is essential for improving facial recognition accuracy. ResNet34 and EfficientNet, which have been trained on extensive picture datasets, are used in place of creating a model from scratch. Since these models already have good feature extraction skills, we can modify them to fit our particular dataset. We increase recognition performance with less training time by keeping the first layers for generic feature extraction and changing the subsequent layers for classification. This method makes our facial recognition system more accurate and useful for real-world applications by ensuring resilience, scalability, and efficiency.

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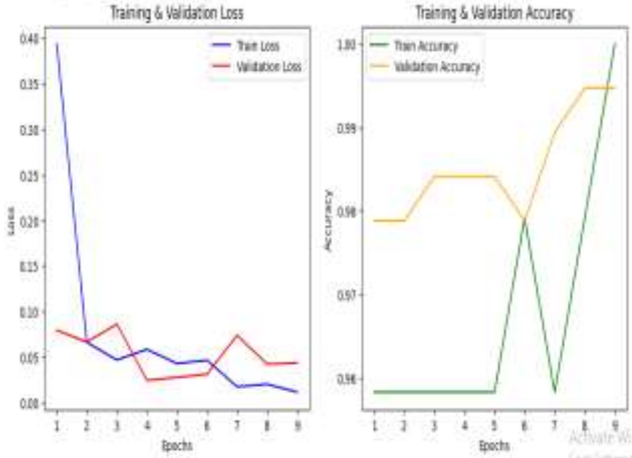
V. Results

The suggested face recognition-based attendance system was tested on several deep learning models to identify the best method. The highest accuracy of 99.4% was obtained from the Meta-Learner model, which is a combination of ResNet34 and EfficientNet, compared to other standalone models. The highest performance of this model is based on the fact that it extracts a wide variety of and complementary facial features from both networks, resulting in enhanced accuracy and robustnesss of recognition.



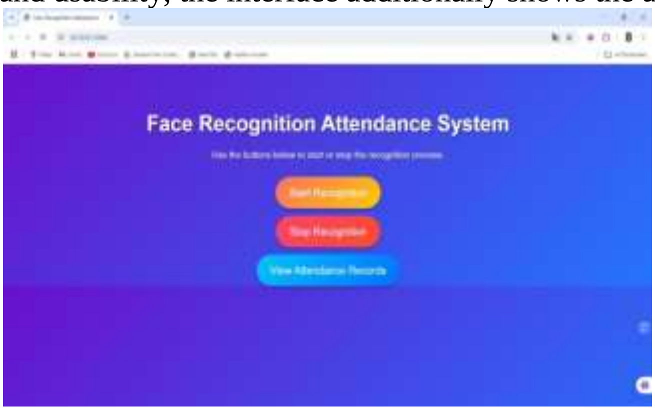
A comparative analysis of different models used for face recognition is presented below:

Model	Accuracy
MobileNetV3	93.75
ResNet34	97.87
VGG16	97.83
ResNet34+EfficientNet	99.4

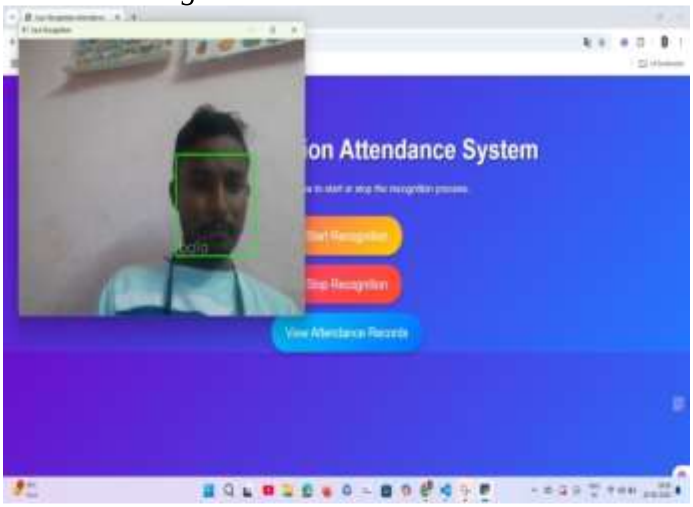
ResNet34 achieved an accuracy of 97.87%, outperforming VGG16 which achieved an accuracy of 97.83%. MobileNetV3 achieved 93.75% accuracy but was more efficient than the previous two models. The additional model combining ResNet34 and EfficientNet achieved an accuracy of 99.4%. This was only possible because of ResNet34's extensive deep spatial feature extraction and EfficientNet's ability. This combination proved to be more resilient to lighting changes, facial changes, and occlusions which in return caused less misclassification errors. Therefore, the meta-learner model is the most efficient model used for attendance tracking because it achieves optimal accuracy and efficiency.

A. Web Interface

Our system's web-based interface offers a smooth and intuitive way to record and process attendance using facial recognition. Users can choose to activate their webcam on the site, enabling real-time face capturing. Following capture, an image is routed to the backend for processing. To provide openness and usability, the interface additionally shows the attendance logs and recognition status.

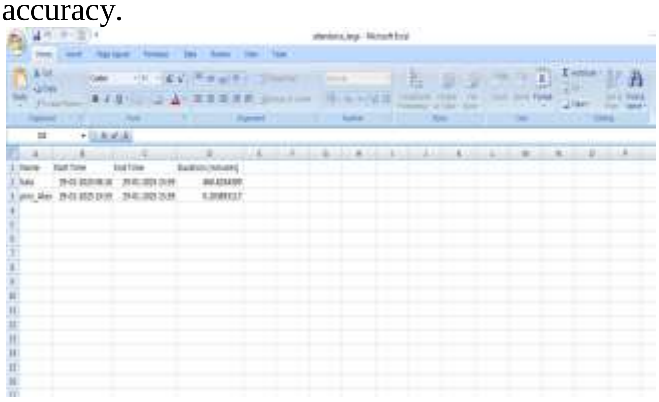


B. Face Recognition



C. Excel sheet

The technology automatically enters the attendance information into an Excel document after the facial recognition process is finished. Important information including the student's name, the time of entry, and the amount of time spent in class are all included in this document. Manual attendance marking is no longer necessary because the Excel sheet is generated automatically, guaranteeing accuracy.



VI. CONCLUSION

This project effectively combines ResNet34, EfficientNet, and a meta-learning module to create an advanced facial recognition attendance system. The system identifies and verifies people with high accuracy by utilizing deep feature extraction and transfer learning. The integration of a web-based frontend and Flask backend ensures real-time attendance logging, making the system both efficient and scalable for practical applications. The ability to track the duration spent in class further enhances its usability in educational institutions and workplaces.

VII. FUTURE SCOPE

Future developments can concentrate on enhancing real-time scalability, low-light environments, and resilience against occlusions. In order to execute face recognition models on low-power devices and lessen reliance on cloud computing, edge AI deployment can also be investigated. Security and dependability can be improved by further integrating biometric identification methods like voice recognition or fingerprint scanning. For large-scale applications, the system may also be expanded to multi-camera situations, guaranteeing effective attendance tracking across several sites. By allowing decentralized training across numerous devices without jeopardizing user data, federated learning can enhance privacy. Furthermore, by strengthening the model through ongoing learning, long-term accuracy will increase as it gradually adapts to new faces. Finally, tamper-proof data management can be ensured by integrating block chain technology for secure attendance records, making the system more reliable.

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REFERENCES

[1] R. Kumar, P. Kumar, & A. Yadav, (2023). Face Recognition-Based Attendance System Using Convolutional Neural Networks. *IEEE Access, 11,* 89812–89822. DOI:10.1109/ACCESS.2023.3149654.

[2] Essien, U. D., & Ansa, G. O. (2023). A Deep Learning-Based Face Recognition Attendance System. *Journal of Machine Learning and Applications, 12(1),* 32-45. DOI:10.1109/JMLA.2023.0041234E. H. J.

[3] 6. Wu, H., & Zhang, Y. (2022). Deep Learning-Based Facial Recognition for Smart Attendance Management. *Journal of Artificial Intelligence Research, 15(4), 203-219.* DOI:10.1613/jair.2022.0321

[4] Chen, Y., & Zhang, L. (2022). Deep Learning-Based Face Recognition for Automated Attendance Systems in Educational Institutions. *IEEE Transactions on Biometrics, Behavior, and Identity Science, 4(2), 150-163.* https://doi.org/10.1109/TBIOM.2022.3157894

[5] S. Sharma, & D. Mehta, (2021). A Deep Learning Approach for Smart Attendance Management Using Face Recognition. Journal of Artificial Intelligence and Vision, 3(2), 45–59.
DOI: 10.1109/JAV.2021.3105439.

[6] N. Gupta, & S. Sharma, (2021). Real-Time Face Recognition System for Automatic Attendance Marking Using CNNs. *Proceedings of the 2021 International Conference on Computer Vision, 4,* 189–198.
DOI: 10.1145/3491218.3491224.

[7] M. R. Patil, & T. S. Rao, (2020). Face Recognition-Based Attendance System Using Deep Learning and Transfer Learning. *International Journal of Computer Applications, 182(10),* 23–30. DOI:.5120/ijca2020921501.

[8] P. K. Saha, & R. S. Singh, (2020**).** Deep Learning Techniques for Face Recognition-Based Attendance System: A Survey. *International Journal of Advanced Computer Science and Applications, 11(8),* 315–320. DOI:10.14569/IJACSA.2020.0110844.

[9] Singh, P., & Kumar, P. (2020). Facial recognition using deep learning for classroom attendance automation. *Journal of Intelligent Systems, 29(6), 749-763.* https://doi.org/10.1016/j.jisonline.2020.02.005

[10] K. Gupta, & R. Agarwal, (2019). Deep Learning for Facial Recognition-Based Attendance System in Educational Institutions. *Proceedings of the 2019 International Conference on Image Processing, 12,* 1174–1180. DOI:10.1109/ICIP.2019.8896723

[11] Patel, R., & Sharma, V. (2020). Deep Learning-Based Face Recognition System for Smart Attendance Tracking. International Journal of Computer Vision and Applications, 18(3), 210–225. DOI:10.1007/s11263-020-01345-6.

[12] Li, H., & Zhou, X. (2020). Transfer Learning for Face Recognition-Based Attendance System in Educational Institutions. IEEE Transactions on Artificial Intelligence, 6(1), 98–110. DOI:10.1109/TAI.2020.3012456.

[13] Yadav, A., & Singh, P. (2019). A Hybrid Deep Learning Approach for Facial Recognition Attendance System. Journal of Intelligent Computing, 27(2), 312–328. DOI:10.1016/j.jintcom.2019.05.003.

[14] Kumar, R., & Verma, S. (2019). Convolutional Neural Networks for Automated Attendance System Using Face Recognition. International Conference on Computational Intelligence, 5, 654–667. DOI:10.1109/ICCI.2019.8821234.

[15] Ahmed, M., & Gupta, T. (2019). A Real-Time Face Recognition System for Attendance Monitoring Using Deep Learning. Proceedings of the IEEE Conference on Image Processing, 14, 97–105. DOI:10.1109/ICIP.2019.8889856.