# Design of face recognition based effective automated smart attendance system


**Jyoti L. Bangare[1], Diptee Chikmurge[2], Karthikeyan Kaliyaperumal[3], Meenakshi[4], Sunil L. Bangare[5], Kishori Kasat[6], Kantilal Pitambar Rane[7], Ravi Kishore Veluri[8], Batyrkhan Omarov[9], Malik Jawarneh[10], Abhishek Raghuvanshi[11]**

[1]Department of Computer Engineering, MKSSS's, Cummins College of Engineering for Women, Savitribai Phule Pune University, Pune, India
[2]School of Computer Engineering, MIT Academy of Engineering, Alandi, India
[3]Deparrtment of Information Technology, Ambo University, Ambo, Ethiopia
[4]School of Journalism and Mass Communication, Apeejay Stya University Sohna Haryana, Gurgaon, India
[5]Department of Information Technology, SavitribaiPhule Pune University, Sinhgad Academy of Engineering, Pune, India
[6]Departmentof Computer Studies, Symbiosis School for Liberal Arts, Symbiosis International (Deemed University), Pune, India
[7]Department of Electronics and Telecommunications Engineering, Bharati Vidyapeeth College of Engineering, Navi Mumbai, India
[8]Department of Computer Science and Engineering, Aditya University, Andhra Pradesh, India
[9]Al-Farabi Kazakh National University, International Information Technology University, Almaty, Kazakhstan
[10]College of Computer Science and Informatics, Amman Arab University, Amman, Jordan
[11]Department of Computer Science and Engineering, Mahakal Institute of Technology, Ujjain, India



**Article Info**

***Article history:***

Received Apr 11, 2024
Revised Jan 10, 2025
Accepted Feb 27, 2025

***Keywords:***

Accuracy
Face recognition
Fuzzy C means
Histogram equalization
K-nearest neighbor
Smart attendance system



**ABSTRACT**

The issue of automatic attendance marking has been successfully resolved in recent years through the utilization of standard biometric approaches. Although this strategy is automated and forward-thinking, its use is hindered by time constraints. Acquiring a thumb impression requires the individual to form a line, which might lead to inconvenience. The innovative visual system utilizes a computer and camera to detect and record students' attendance based on their facial features. This article presents a face recognition based automatic attendance system. This system includes- image acquisition, image enhancement using histogram equalization, image segmentation by fuzzy C means clustering technique, building classification model using K-nearest neighbour (KNN), support vector machine (SVM) and AdaBoost technique. For experimental work, 500 images of students of a class are selected at random. Accuracy of KNN algorithm in proposed framework is 98.75%. It is higher than the accuracy of SVM (96.25%) and AdaBoost (86.50%). KNN is also performing better on parameters like-sensitivity, specificity, precision and F_measure.





***Corresponding Author:***

Abhishek Raghuvanshi
Department of Computer Science and Engineering, Mahakal Institute of Technology
Ujjain, India
Email: abhishek14482@gmail.com


## 1. INTRODUCTION

The examination of biological data, often known as biometrics, is gaining significance in the current technology landscape. In contemporary times, when individuals want to authenticate someone's identification by the examination of their fingerprints, facial features, behavioural characteristics, or signature, they commonly refer to the field of biometrics. Biometrics provides a very reliable form of authentication compared to ID cards, keys, PINs, passwords, or other outdated techniques due to the individuality of a person's physical and behavioural characteristics. Biometrics serves as a kind of identification and access control, providing realistic verification. Moreover, it can be employed to ascertain the identity of a specific person. Biometric identifiers are distinct, quantifiable, and durable traits that are used to define and describe an individual [1].

Biometric technologies, including fingerprint, smart card, digital signature, and web-based systems, are extensively utilized in various companies throughout all developed countries. This obviates the necessity for any supplementary devices to discern the learners. From an administrative standpoint, attendance is essential and advantageous when assessing an organization. Recording attendance via traditional methods is a laborious and time-consuming process. The primary impetus for developing this technology is to provide an efficient automated system for monitoring attendance using facial detection and identification. In contrast to the traditional approach of recording attendance, this modern method is more accurate and demands less exertion [2]. Moreover, this system is advantageous for the purposes of authentication, surveillance, and record keeping in the management of educational institutions such as schools, colleges, and universities. Consistently attending classes is crucial for a student's academic achievement. An automated visual system is more essential as the number of students in educational institutions continues to rise, leading to a commensurate increase in demand [3].

A face identification system refers to one or more computer programs that assist in the verification or identification of an individual based on a digital picture or video outline obtained from a video source. An approach to accomplish this is by conducting a comparison between a face database and specific facial characteristics extracted from the image. The face-based identification system may accurately recognize and authenticate an individual by using a digital camera or video camera [4]. The technology gathers images of individuals in a community area, connects with the surveillance system, and incorporates a pre-existing database. Facial recognition systems have a broad range of applications, including verifying static "mug-shot" images and identifying faces in uncontrolled contexts such as airports. One established method for this technique is to shape the facial features, including the ears, eyebrows, eyes, lips, nose, and chin, and consider their three-dimensional relationship [5].

Face recognition is a popular and readily apparent use of digital image processing. One application of facial recognition is the identification of individuals inside an organization to promote their involvement. To assess the functioning of an organization, it is crucial to maintain a database of participation records. The decision to incorporate participation into the board architecture was motivated by the desire to mechanize the conventional method of assessing involvement. The automated attendance identification system autonomously verifies and examines participation on a daily basis, with minimal human involvement [6].

Figure 1 shows proposed architecture of automatic face identification system, it automatically detects (recognize) and identifies multiple faces from group photograph. In this automated method, input picture is unknown faces and system gives back output to the identity from dataset of multiple persons. Thus, the test faces should be compared to all trained pictures present in the dataset for getting the identified picture. Match face will mark automatically for attendance and is saved in separate database file. Image acquisition entails capturing a photograph using a suitable camera. Before commencing any video or image processing, it is necessary to capture a photograph using the camera and convert it into a measurable entity. The procedure referred to as image acquisition aims to convert an optical image into a set of mathematical data that may be further processed on a computer [7]. Face detection involves determining the presence of a face in a photograph and, if present, providing information on the location and appearance of the face in the image. Automatic face detection is a computer-based technique used to assess the size and position of a person's face in a digital image. Face detection is the initial step in any face preparation framework. It serves various purposes, including face identification, enhancing beauty care products, categorizing by sex, grouping, and extracting facial components [8].

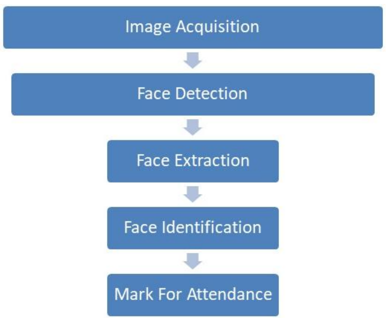


Figure 1. Steps involved in automatic face identification

Facial feature extraction is the identification of distinct regions of the face, including the eyes, forehead, lips, nose, jawline, and other locations. Over the course of their lifespan, individuals possess the ability to differentiate between numerous distinct visual characteristics and effortlessly recognize faces. Precision in identifying faces and other facial features is crucial in several domains, such as human-computer interaction, face activity and display, face recognition, and face photo database administration. An important enhancement in these applications is the capability to differentiate between various facial highlights. Facial element extraction is a significant advancement in human face recognition. Facial recognition plays a crucial role in several applications within the domains of human-computer interaction and facial recognition itself [9]. Face identification aims to authenticate or distinguish an individual's identity based on their facial features. By employing a face recognition framework, individuals may be accurately identified in both photos and videos. The facial recognition system employs a computer algorithm to choose specific and unequivocal details regarding an individual's face. To facilitate comparison with data from other instances in a face recognition dataset, intricate facial characteristics like the distance between the eyes or the location of the jaw are converted into a numerical format. Face formats save specific data about each individual face and may be easily differentiated from photographs due to their purpose of including only the necessary information for distinguishing one face from another [10].

This article introduces a facial recognition system that automatically records attendance. This system comprises of many components: picture capture, image augmentation by histogram equalization, image segmentation using the fuzzy C means clustering approach, and the construction of a classification model using the K-nearest neighbour (KNN), support vector machines (SVM), and AdaBoost techniques. The accuracy of the given method surpasses that of SVM (96.25%) and AdaBoost (86.50%). KNN demonstrates superior performance in terms of sensitivity, specificity, accuracy, and F_measure.

## 2. RELATED WORK

### 2.1. Face recognition

Authors developed an innovative facial recognition technique to determine a person's interests using only a portion of their face. Furthermore, they have provided two facial photographs in order to extract the essential characteristics. Furthermore, they have developed a point set matching method that utilises discriminative matching on textual features to perform the matching function. In addition, they have discovered a point set matching technique that is capable of simultaneously matching both the extracted characteristics and the face photographs. After considering all factors, the proximity of the acknowledged significant characteristics is determined by examining the similarity of the two altered facial images. The findings indicate that the investigations, which utilised a facial dataset, were efficacious [11].

In order to gain a deeper comprehension of the numerous recurring elements in facial images, Researchers developed a novel convolutional neural network (CNN) known as the wasserstein convolutional neural network (WCNN). The process of understanding the modalities and invariants of features is distributed across three levels in the WCNN. In addition, a WCNN layer is utilised to calculate the distance, which represents the dissimilarity of the feature distributions. In addition, a correlation is incorporated to reduce the magnitude of the parameter and mitigate the risk of overfitting. Finally, they have proven that their WCNN surpasses other learning algorithms in terms of prediction accuracy [12]. In this method, authors have created a new method for generating realistic faces with high resolution. This method combines texture inpainting and position correction, which are two separate components. They used an innovative warping approach to merge the two parts into a profound network. In addition, they have demonstrated the inclusion of the corrective component, the simplification of heterogeneous face synthesis from unpaired to paired images during translation, and the mitigation of posture and spectral inconsistencies in heterogeneous face image identification. Finally, they have simplified the process of achieving precise facial recognition [13].

In order to reduce the occurrence of disparities in facial characteristics, authors have developed an innovative facial augmentation network. A unique hierarchical disentanglement module was developed to separate features from identity representation. Furthermore, graph convolutional networks are utilised to extract geometric information by uncovering the relationships between geographically distinct regions that are conserved. The experimental results substantiated the superiority of the proposed methodology over the alternative approaches [14]. Work in [15] presented a new method for Joint Group Sparse Principle Component Analysis. This strategy enforced a set of conditions on the basic coefficients to ensure that they were regarded simultaneously sparse. Their methodology ensured the preservation of the traits. Finally, they have validated their methodology by considering both the compressed image and facial recognition. Their methodology surpasses the most advanced techniques in terms of selecting relevant features and achieving high accuracy in facial recognition [15].

A novel classification approach consisting of four steps has been proposed: feature selection, detection, iteration, and conversion. Initially, a non-linear function is employed to select the appropriate feature during the feature selection phase. Furthermore, spatial parameters are employed to detect distinctive characteristics in the hyperspectral image (HIS) data, which are subsequently taken into account during the evaluation of potential HSI face candidates. Next, in the iterative approach, the Gaussian filter is used as the third step. Finally, to achieve effective categorization, the real-time maps are transformed into distinct values using Otsu's method. Their approach surpasses the others in terms of accuracy and the frequency of wrong categorization when compared to competing approaches [16]. Work in [17] developed a spectrum band selection method that combines the clustering methodology, Gabor filter, and gradient method. This method effectively extracts information while reducing the impact of noise. Furthermore, for the purpose of doing a comparison analysis, the nearest neighbour aware classifier integrates the Hog and Gabor features. Finally, the experimental findings illustrate the effectiveness of their strategy in terms of time complexity [17].

To tackle the issue of tiny section set problem, researchers proposed a unique CNN architecture that employs lightweight components to achieve efficient classification. Their research focuses on reducing the dimensionality of images and using spatio-spectral Schrodinger Eigen maps to find important features in order to obtain integrated spatial-spectral image data. In addition, they have created a convolution model that can handle features obtained from data points in a one-dimensional vector viewpoint, using a dual-scale approach. Subsequently, the researchers employed the innovative Bi-channel fusion method to selectively refine the features acquired using dual scale convolution [18]. Ultimately, a global average pooling classifier is employed to enhance the accuracy of classifying hyperspectral images with a limited number of labelled samples by merging and including the filtered characteristics.

### 2.2. Feature selection techniques

Research work [19] introduced a novel feature selection method using a wrapper-based approach. When constructing the random forest for categorization, the creators of this model considered two essential factors: cooperativeness and co-evaluation. In addition, the scientists employed two distinct sets of data-a benchmark dataset and a collection of datasets obtained from clinics-to evaluate and contrast their feature selection technique with a classification algorithm based on random forests. Their methodology was shown to enhance the decision-making abilities of healthcare workers by reducing the time used for categorising and improving the accuracy of classification [19].

Work done in [20] developed a new method for face recognition called spectrum based discriminative deep learning (DL). This method involves training the samples in a subspace. Their research revealed the ability to distinguish between different types of face samples within the same spectrum, as well as between different spectra. Finally, they have enhanced the accuracy of their prediction approach and assessed it by conducting many tests using three separate datasets: HK PolyU, CMU, and UWA [20]. Sachin &Birmohan developed a novel model for detecting phishing utilising KNN and Binary Modified Equilibrium Optimisation, along with a newly developed AV-shape transfer technique. Their model has the capability to do classification and optimisation tasks, as well as feature selection, due to its robust levels of exploration and exploitation. A statistical validation was undertaken by comparing 17 strategies in order to assess classification accuracy and the selection of features from 18 different datasets [21].

Khare *et al.* [22] proposed a new model for feature selection that combines two current optimisation algorithms, namely the Spider Monkey Optimisation algorithm and the Paddy Field Algorithm, using a bio-inspired approach. They employed a wrapper strategy for feature selection. The task of classification was performed using SVMs. Validation was conducted using ten-fold cross validation. The proposed approach was evaluated using a real-time benchmark dataset. They showed that employing TPM (true positive, false negative, true positive, and false negative) analysis for assessing accuracy using precision and recall enhances classification accuracy. By employing swarm intelligence-based optimisation, their studies highlighted the efficacy of their proposed feature selection method in effectively reducing the number of features to an ideal level. However, via the process of experimenting with alternative classification strategies, their model has the potential to become even more precise [22].

### 2.3. Classification

Jain *et al.* [23] developed an advanced classification model that utilizes SVM and self organising maps (SOM) to categorise pixels as either inside or exterior based on the comparison of posterior probability pixel intensities. They have shown that their model surpasses the existing methods in terms of classification accuracy, as evaluated by Kappa statistics values [23]. Work in [24] utilised random forest and principal component analysis to develop a novel classifier that incorporates allthree sets of attributes. Subsequently, to determine the optimal characteristics for constructing their novel classifier, they have narrowed down the features depending on the accuracy attained by their new classifier. Additional research is carried out to determine the optimal hyperparameters for the random forest classifier. The optimal random forest and KNN models have both determined a significance threshold of 0.05 [24].

Research work in [25] conducted various experiments on the modified national institute of standards and technology (MNIST) dataset to assess and examine the performance of conventional machine learning (ML) and deep learning (DL) models for image categorization. By utilising a vast and commonly used image dataset as the input, they have achieved a CNN accuracy of 98% and a SVM accuracy of 88%. They have achieved an accuracy of 83% for CNN and 86% for SVM, while using limited image datasets [25]. The spectral dimension, initially introduced by [26] enhances object detection in relation to images and enables the advancement of a robust facial recognition system. The spectral dimension of a HSI enhances the precision of face identification by enhancing the level of detail in the image. By employing band fusion and band selection techniques, a remarkable accuracy of 97.3% was achieved in the field of facial recognition [26].

Taherkhani *et al.* [27] developed a novel framework that integrates the CNN and sparsity learning approach to determine the most effective spectral bands for optimal performance in face recognition. Specifically, once all the bands have been processed by a CNN, the filters in the initial layer of the CNN are regularised using a group Lasso technique to remove redundant bands during the training process. In order to get the best possible performance in the face recognition technique, they have selected the most suitable spectral bands. Experiments using HSI datasets achieved higher classification accuracy than the most advanced algorithms currently available [27].

Research work [28] employed a DL methodology to develop a novel network that addresses the issues and enhances the accuracy of HSI categorization. Their 3D CNN is a sophisticated DL architecture that enhances classification accuracy. In order to ensure the accuracy and reliability of the data, the DL architecture utilises spectral and spatial dense connectivity. The authors propose acquiring and utilising the pertinent characteristics via a spectral and spatial division. Furthermore, they have employed several optimisation methods such as regularisation, normalisation, dropout, data augmentation, and learning rate adjustments to address the issues and enhance the accuracy of classification. Ultimately, they conducted a comprehensive series of tests to demonstrate that their DL framework surpassed the competition, with a remarkable accuracy rate of 99% [28].

## 3. PROPOSED METHODOLOGY

This section introduces a facial recognition system that automatically records attendance system as shown in Figure 2. This system comprises of many components: image acquisition. Acquired images contain noises. Histogram equalization is used to remove noises from images and also to enhance image quality. Image segmentation is conducted using the fuzzy C means clustering approach, and the construction of a classification model using the KNN, SVM, and AdaBoost techniques. A random selection of 500 photos of pupils from a class is made for experimental purposes. The suggested framework achieves a 98.75% accuracy for the KNN algorithm. KNN demonstrates superior performance in terms of sensitivity, specificity, accuracy, and F_measure.

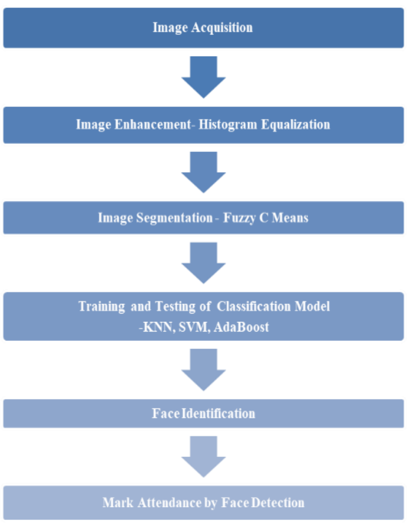


Figure 2. Machine learning based automated smart attendance system

Utilizing histogram equalization, a basic method in image processing may provide pictures of enhanced clarity and detail. High-definition photos are essential for accurately identifying images. By applying histogram equalization to the final picture, any previously suppressed sounds will be restored when all the processing is finished. This approach is often used in image preprocessing. This approach generates a histogram of grey levels that are consistently smooth and perfect by determining the grey mapping of the picture using grey operations [29].

The clustering technique seeks to identify the underlying relationships between pixels in a picture by organizing similar patterns into groups. Clustering is the process of classifying items into groups based on common characteristics. When the FCM approach is used, data objects are organized into sets according to their membership values. When maximizing the objective function, the method of least squares is used, and upon calculation, the final data is divided [30].

For classification purposes, the KNN method, which is a kind of supervised algorithm, is the most reliable choice. It is important to note that this technique constantly produces identical outcomes, regardless of the training data used. Each sample may be classified based on its similarity to the population value, with only a few samples being allocated a class. The equation provided provides the Euclidean distance as a means to quantify the similarity between two-pixel positions. Considering these factors, it would have been preferable for the pixels to be initially grouped together, and that is precisely what occurs. The KNN algorithm identifies the neighbourhood with the minimum distance between any two neighbours, which is denoted by the letter K. Primarily, consider the quantity of residences in the vicinity. When there are just two courses, it is quite likely that there will be an odd number of them. The number K = 1 is used for the calculation of the nearest neighbour at that particular step in the algorithm. If this were to happen, it would be the most straightforward and uncomplicated result [31].

SVMs are a kind of discriminative classifier that mathematically represents a decision boundary in a single hyperplane. Nevertheless, when new models are built utilizing stamped preparation data, the computation yields an optimal hyperplane. Find a linear boundary that can effectively distinguish between two sets of 2D centres by following a distinct trajectory. Data may be partitioned and a methodology can be shown using SVM. These include several computational algorithms and supervised learning models. Usually, SVM is used for representation and regression analysis. SVM are used to tackle the issue of classifying many classes. The objective of the figure is to determine the position of the class hyperplane. Furthermore, alongside the hyperplanes that scatter the data, two symmetrical hyperplanes are also expanding [32].

AdaBoost is a method that may be used to train classifiers that are not very effective in accurately categorizing data, with the aim of improving their accuracy. The AdaBoost method will be used to allocate initial weights to each observation. Observations that were incorrectly categorized will be assigned more importance after a few cycles, whilst those that were correctly classified would be assigned lesser importance. By applying weights to observations according to their respective classes, we may significantly improve the performance of the classifier. As a result, there are fewer instances of incorrect categorization. The technique of “boosting” involves implementing a sequence of tailored adjustments to pupils who are experiencing academic challenges. As the series advances, each subsequent model assigns more importance to data that were previously given less emphasis [33].

## 4. EXPERIMENTAL SETTING AND RESULT ANALYSIS

To carry out the experiment, a selection of 500 photographs of students from a certain class is made using a random sampling method. The training set comprises 400 photographs, whilst the testing set consists of 100 pictures. The input image contains many auditory stimuli. Histogram equalization filters are used to remove or significantly minimize unwanted disturbances. After removing noise, histogram equalization is a promising option for improving the quality of an image. Classification model is built using KNN, SVM, and AdaBoost techniques. Metrics such as accuracy, sensitivity, specificity, precision and F_measure are used in the evaluation process to evaluate performance. KNN is performing much better than the other methods used in the framework. Results are presented in Table 1 and Figure 3. Accuracy of KNN algorithm in proposed framework is 98.75%. It is higher than the accuracy of SVM (96.25%) and AdaBoost (86.50%). KNN is also performing better on parameters like- sensitivity, specificity, precision and F_measure.

Table 1. Results of KNN, SVM and AdaBoost algorithm for face recognition based smart attendance system

| | Accuracy | Sensitivity | Specificity | Precision | F_Measure |
|---|---|---|---|---|---|
| AdaBoost | 86.50 | 94.25 | 93.50 | 93.25 | 88.75 |
| SVM | 96.25 | 96.50 | 95.75 | 94.50 | 95.25 |
| KNN | 98.75 | 98.25 | 98.25 | 98.50 | 98.75 |

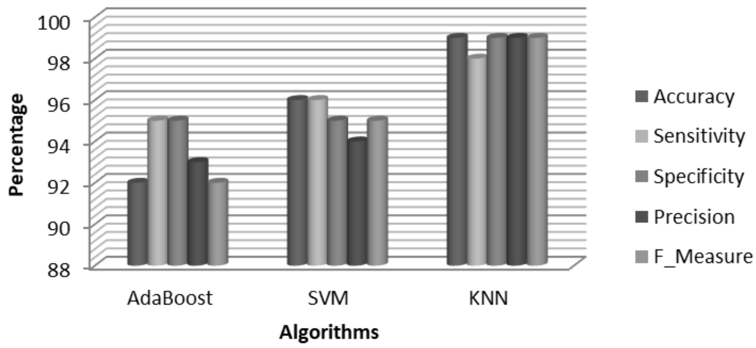


Figure 3. Performance of KNN, SVM and AdaBoost algorithm for face recognition based smart attendance system

## 5. CONCLUSION AND FUTURE WORK

An automated attendance system based on facial recognition is presented in this article. This system consists of acquisition of images, image segmentation using fuzzy C means clustering, image augmentation using histogram equalization, and the construction of a classification model utilizing KNN, SVM, and AdaBoost techniques. The facial recognition system can effectively identify and verify an individual's identity by utilizing a digital camera or video camera. The device captures photographs of individuals in a community area, links with the surveillance system, and integrates with an existing database. 500 photos of a class's students are chosen at random for the experiment. In the suggested framework, the KNN algorithm's accuracy is 98.75%. It surpasses the accuracy of AdaBoost (86.50%) and SVM (96.25%). Additionally, KNN is outperforming other models in terms of F_measure, sensitivity, specificity, and accuracy. In near future, attendance system proposed in this paper can be upgraded to work in real time environment by using IoT based cameras and devices.

## ACKNOWLEDGEMENTS

We are deeply thankful to our institutions for providing the necessary resources and facilities that enabled the successful completion of this research.

## FUNDING INFORMATION

No funding received for this reasearch work

## AUTHOR CONTRIBUTIONS STATEMENT

| Name of Author | C | M | So | Va | Fo | I | R | D | O | E | Vi | Su | P | Fu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jyoti L. Bangare | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | ✓ | |
| Diptee Chikmurge | | ✓ | | | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| Karthikeyan Kaliyaperumal | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | ✓ | |
| Meenakshi | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | ✓ | |
| Sunil L. Bangare | | ✓ | | | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| Kishori Kasat | | | ✓ | ✓ | | | ✓ | | | ✓ | ✓ | | ✓ | ✓ |
| Kantilal Pitambar Rane | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | ✓ | |
| Ravi Kishore Veluri | ✓ | | ✓ | ✓ | ✓ | | | | | | | | | |
| Batyrkhan Omarov | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | ✓ | |
| Malik Jawarneh | ✓ | ✓ | ✓ | ✓ | | | | | | | | | | |
| Abhishek Raghuvanshi | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | ✓ | |

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

## CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

## INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

## ETHICAL APPROVAL

Ethical approval was not required for this study, as it did not involve human or animal subjects.

## DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

## REFERENCES


[1] V. Rohini, M. Sobhana, and C. S. Chowdary, "Attendance monitoring system design based on face segmentation and recognition," *Recent Patents on Engineering*, vol. 16, Apr. 2022, doi: 10.2174/1872212116666220401154639.

[2] M. Z. Khan, S. Harous, S. U. Hassan, M. U. G. Khan, R. Iqbal, and S. Mumtaz, "Deep unified model for face recognition based on convolution neural network and edge computing," in *IEEE Access*, vol. 7, pp. 72622-72633, 2019, doi: 10.1109/ACCESS.2019.2918275.

[3] K. Alhanaee, M. Alhammadi, N. Almenhali, and M. Shatnawi, "Face recognition smart attendance system using deep transfer learning," *Procedia Computer Science*, vol. 192, pp. 4093–4102, 2021, doi: 10.1016/j.procs.2021.09.184.

[4] S. Bhattacharya, G. S. Nainala, P. Das, and A. Routray, "Smart attendance monitoring system (SAMS): a face recognition-based attendance system for classroom environment," *IEEE Xplore*, Jul. 01, 2018, https://ieeexplore.ieee.org/abstract/document/8433537

[5] S. Sawhney, K. Kacker, S. Jain, S. N. Singh, and R. Garg, "Real-time smart attendance system using face recognition techniques," *2019 9th International Conference on Cloud Computing, Data Science and Engineering (Confluence)*, Noida, India, 2019, pp. 522-525, doi: 10.1109/CONFLUENCE.2019.8776934.

[6] M. S. S. Sarnin, M. A. Idris, N. F. Naim, and A. Kadir, "Smart attendance system using face recognition," *Springer Proceedings in Physics*, pp. 695–708, Jan. 2023, doi: 10.1007/978-981-19-9267-4_68.

[7] L. N. Thalluri *et al.*, "Automated face recognition system for smart attendance application using convolutional neural networks," *International Journal of Intelligent Robotics and Applications*, Jan. 2024, doi: 10.1007/s41315-023-00310-1.

[8] Nurkhamid, P. Setialana, H. Jati, R. Wardani, Y. Indrihapsari, and N. M. Norwawi, "Intelligent attendance system with face recognition using the deep convolutional neural network method," *Journal of Physics: Conference Series*, vol. 1737, no. 1, p. 012031, Jan. 2021, doi: 10.1088/1742-6596/1737/1/012031.

[9] A. S. Nadhan *et al.*, "Smart attendance monitoring technology for industry 4.0," *Journal of Nanomaterials*, vol. 2022, pp. 1–9, Jun. 2022, doi: 10.1155/2022/4899768.

[10] R. Ullah *et al.*, "A real-time framework for human face detection and recognition in CCTV images," *Mathematical Problems in Engineering*, vol. 2022, pp. 1–12, Mar. 2022, doi: 10.1155/2022/3276704.

[11] R. Weng, J. Lu, Y. -P. Tan, and J. Zhou, "Learning cascaded deep auto-encoder networks for face alignment," in *IEEE Transactions on Multimedia*, vol. 18, no. 10, pp. 2066-2078, Oct. 2016, doi: 10.1109/TMM.2016.2591508.

[12] R. He, J. Cao, L. Song, Z. Sun and T. Tan, "Adversarial cross-spectral face completion for NIR-VIS face recognition," in *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 42, no. 5, pp. 1025-1037, 1 May 2020, doi: 10.1109/TPAMI.2019.2961900.

[13] R. He, X. Wu, Z. Sun, and T. Tan, "Wasserstein CNN: learning invariant features for NIR-VIS face recognition," IEEE *Transactions on Pattern Analysis and Machine Intelligence*, vol. 41, no. 7, pp. 1761–1773, Jul. 2019, doi: 10.1109/tpami.2018.2842770.

[14] M. Luo, J. Cao, X. Ma, X. Zhang, and R. He, "FA-GAN: face augmentation GAN for deformation-invariant face recognition," in *IEEE Transactions on Information Forensics and Security*, vol. 16, pp. 2341-2355, 2021, doi: 10.1109/TIFS.2021.3053460.

[15] Z. Khan, F. Shafait and A. Mian, "Joint group sparse PCA for compressed hyperspectral imaging," in *IEEE Transactions on Image Processing*, vol. 24, no. 12, pp. 4934-4942, Dec. 2015, doi: 10.1109/TIP.2015.2472280.

[16] B. Xue *et al.*, "A subpixel target detection approach to hyperspectral image classification," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 55, no. 9, pp. 5093-5114, Sept. 2017, doi: 10.1109/TGRS.2017.2702197.

[17] Q. Chen, J. Sun, V. Palade, X. Shi, and L. Liu, "Hierarchical clustering-based band selection algorithm for hyperspectral face recognition," in *IEEE Access*, vol. 7, pp. 24333-24342, 2019, doi: 10.1109/ACCESS.2019.2897213.

[18] S. Jia *et al.*, "A lightweight convolutional neural network for hyperspectral image classification," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 59, no. 5, pp. 4150-4163, May 2021, doi: 10.1109/TGRS.2020.3014313.

[19] V. R. E. Christo, H. K. Nehemiah, J. Brighty, and A. Kannan, "Feature selection and instance selection from clinical datasets using co-operative co-evolution and classification using random forest," *IETE Journal of Research*, pp. 1–14, Jan. 2020, doi: 10.1080/03772063.2020.1713917.

[20] F. Wu, X.-Y. Jing, Y. Feng, Y. Ji, and R. Wang, "Spectrum-aware discriminative deep feature learning for multi-spectral face recognition," *Pattern Recognition*, vol. 111, p. 107632, Mar. 2021, doi: 10.1016/j.patcog.2020.107632.

[21] S. Minocha and B. Singh, "A novel phishing detection system using binary modified equilibrium optimizer for feature selection," *Computers and Electrical Engineering*, vol. 98, p. 107689, Mar. 2022, doi: 10.1016/j.compeleceng.2022.107689.

[22] N. Khare *et al.*, "SMO-DNN: Spider monkey optimization and deep neural network hybrid classifier model for intrusion detection," *Electronics*, vol. 9, no. 4, p. 692, Apr. 2020, doi: 10.3390/electronics9040692.

[23] D. K. Jain *et al.*, “An approach for hyperspectral image classification by optimizing SVM using self organizing map,” *Journal of Computational Science*, vol. 25, pp. 252–259, Mar. 2018, doi: 10.1016/j.jocs.2017.07.016.
[24] J. Gao, D. Nuyttens, P. Lootens, Y. He, and J. G. Pieters, “Recognising weeds in a maize crop using a random forest machine-learning algorithm and near-infrared snapshot mosaic hyperspectral imagery,” *Biosystems Engineering*, vol. 170, pp. 39–50, Jun. 2018, doi: 10.1016/j.biosystemseng.2018.03.006.
[25] P. Wang, E. Fan, and P. Wang, “Comparative analysis of image classification algorithms based on traditional machine learning and deep learning,” *Pattern Recognition Letters*, vol. 141, Aug. 2020, doi: 10.1016/j.patrec.2020.07.042.
[26] R. Senthilkumar, V. Srinidhi, S. Neelavathi and S. R. Devi, “Face recognition using hyperspectral imaging and deep learning,” *2018 Tenth International Conference on Advanced Computing (ICoAC)*, Chennai, India, 2018, pp. 377-382, doi: 10.1109/ICoAC44903.2018.8939108.
[27] F. Taherkhani, J. Dawson, and N. M. Nasrabadi, “Hyperspectral band selection for face recognition based on a structurally sparsified deep convolutional neural networks,” *2019 International Conference on Biometrics (ICB)*, Crete, Greece, 2019, pp. 1-8, doi: 10.1109/ICB45273.2019.8987360.
[28] X. Zhang *et al.*, “SSDANet: spectral-spatial three-dimensional convolutional neural network for hyperspectral image classification,” in *IEEE Access*, vol. 8, pp. 127167-127180, 2020, doi: 10.1109/ACCESS.2020.3008029.
[29] J. Kolli, S. Chaluvadi, V. M. Manikandan and Y. -C. Hu, “An efficient face recognition system for person authentication with blur detection and image enhancement,” 2022 *1st International Conference on Sustainable Technology for Power and Energy Systems (STPES)*, SRINAGAR, India, 2022, pp. 1-6, doi: 10.1109/STPES54845.2022.10006633.
[30] M. K. Gibran, E. B. Nababan and P. Sihombing, “Analysis of face recognition with fuzzy c-means clustering image segmentation and learning vector quantization,” 2020 3rd *International Conference on Mechanical, Electronics, Computer, and Industrial Technology (MECnIT)*, Medan, Indonesia, 2020, pp. 188-193, doi: 10.1109/MECnIT48290.2020.9166649.
[31] K. Sasirekha and K. Thangavel, “Optimization of K-nearest neighbor using particle swarm optimization for face recognition,” *Neural Computing and Applications*, vol. 31, no. 11, pp. 7935–7944, Jul. 2018, doi: 10.1007/s00521-018-3624-9.
[32] S. B. Chaabane, M. Hijji, R. Harrabi, and H. Seddik, “Face recognition based on statistical features and SVM classifier,” *Multimedia Tools and Applications*, vol. 81, no. 6, pp. 8767–8784, Feb. 2022, doi: 10.1007/s11042-021-11816-w.
[33] B. Thilagavathi, K. Suthendran, and K. Srujanraju, “Evaluating the AdaBoost algorithm for biometric-based face recognition,” *Lecture Notes on Data Engineering and Communications Technologies (Online)*, pp. 669–678, Jan. 2021, doi: 10.1007/978-981-16-0081-4_67.

## BIOGRAPHIES OF AUTHORS

**Jyoti L. Bangare** is an assistant professor in Department of Computer Engineering, MKSSS’s, Cummins College of Engineering for Women, Savitribai Phule Pune University, Pune, India. Her research interests include educational data mining, healthcare analytics, ML, and image processing. She can be contacted at email: jyoti.bangare@cumminscollege.in.

**Diptee Chikmurge** MIT Academy of Engineering, Alandi, Pune, India. She can be contacted at email: diptee.chikmurge@mitaoe.ac.in.

**Dr. Karthikeyan Kaliyaperumal** is associate professor in IT@IoT - HH Campus in Ambo University at Ambo, Ethiopia. He is having 20 years of teaching experience. He can be contacted at email: karthikeyan@ambou.edu.et.

**Dr. Meenakshi** is an expert in Media and International Relations, Intercultural Communication, Event Management, Radio and TV Journalism and has a background in Continental Philosophy. She has taught these subjects for nearly 11 years at universities such as the Kurukshetra University (Haryana, India), LLDIMS, GGSIP University (Delhi, India), Lovely Professional University (Punjab, India), GD Goenka University (India) and at Apeejay University, India. She can be contacted at email: mt6458@gmail.com.

**Dr. Sunil L. Bangare** working as an associate professor in the Department of Information Technology at Sinhgad Academy of Engineering, Pune, India. He graduated in Bachelor of Engineering in Electronics and Telecommunication at Amravati University (SGBAU), Amravati, Maharashtra, India. He secured Master of Technology in Information Technology at Bharati Vidyapeeth Deemed University, Pune, India. He completed Ph.D. in the field of Computer Science and Engineering at Koneru Lakshmaiah Education Foundation (K. L. University), Vaddeswaram, India. He completed his PGD C-DAC. He is a Fellow (FIE)-The Institution of Engineers (India). He is in teaching profession for more than 16 years and have 1.6 years of industrial experience. He can be contacted at email: sunil.bangare@gmail.com.

**Dr. Kishori Kasat** is working as associate professor in Computer Studies Department, Symbiosis School for Liberal Artsin Symbiosis International (Deemed University, Pune, India. She can be contacted at email: kishori.kasat@ssla.edu.in**.**

**Dr. Kantilal Pitambar Rane** received B.E. degree in Electronics and Telecommunication Engineering from North Maharashtra University, Jalgaon in 1996. M.E. Degree in Electronics Engineering from Shivaji University, Kolhapur in 2005. Ph.D. degree in Electronics Engineering from North Maharashtra University, Jalgaon in 2013. He is currently working as Professor at Bharati Vidyapeeth College of Engineering Navi Mumbai, India. His research interests include image processing, IoT, AI, and ML. He can be contacted at email: kantiprane@rediffmail.com.

**Ravi Kishore Veluri** is working as associate professor in CSE, Aditya University, Surampalem Andhra Pradesh, India. He can be contacted at email: ravikishorev1985@gmail.com.

**Batyrkhan Omarov** received his bachelor's and master's degrees from Al-Farabi Kazakh National University, Almaty, Kazakhstan in 2008 and 2010, respectively. In 2019, he received his Ph.D. from Tenaga National University, Kuala Lumpur, Malaysia. His research interests include ML, DL, data science, image processing, medical image analysis, and AI in medicine. He can be contacted at email: batyahan@gmail.com.

**Malik Jawarneh** College of Computer Science and Informatics, Amman Arab University. Jordan. He can be contacted at email: M.jawarneh@aau.edu.jo.

**Dr. Abhishek Raghuvanshi** is working as Dean Academics and Professor of Computer Science and Engineering in Mahakal Institute of Technology in Ujjain in India. He is having teaching experience of 19 years, research experience of 15 years and administrative experience of 11 years. His research areas include- ML, IoT security, and health care analytics. He is having many publications in SCI and Scopus indexed journals. He has also worked on many governments of India funded research projects. He can be contacted at email: abhishek14482@gmail.com.