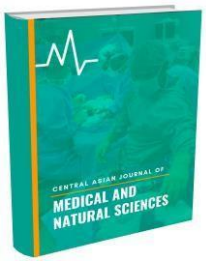

CENTRAL ASIAN JOURNAL OF MEDICAL AND NATURAL SCIENCES
https://cajmns.centralasianstudies.org/index.php/CAJMNS
*Volume: 07 Issue: 01 | January 2026 ISSN: 2660-4159*

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*Article*

# AI-Powered Attendance Management System Using Facial Recognition

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**Abstract:** Traditional ways of keeping track of attendance, including signing in by hand or swiping an ID card, can take a long time, be wrong, and be open to proxy attendance. This project presents an Attendance Management System Using Facial Recognition to solve these problems. This system is faster, more accurate, and safer than the current ones. The system uses cutting-edge facial recognition technology to automatically find and recognize student faces in real time. The system uses a pre-trained deep learning model and a high-resolution camera to take pictures, identify people, and mark attendance without any help from a person. Face detection and identification algorithms make sure that the results are quite accurate, even when the lighting or face expressions change. The program has a simple UI and capabilities like automatic attendance tracking, reporting, and data storage. It also makes attendance reports in real time, which cuts down on the work of administrators and makes everything run more smoothly. This approach makes attendance monitoring more reliable while lowering the chance of fake entries. Possible future improvements include support for larger datasets through continuous model training, integration with mobile devices, and cloud-based data storage. The study shows how AI and computer vision may make common administrative jobs easier for schools and businesses.

**Keywords:** Deep Learning, Local Binary Patterns, False Acceptance Rate, Biometric System, Convolutional Neural Networks, Data Flow Diagrams, Local Binary Pattern Histogram

**Citation:** Sivakani R., Shynu T., Ali M. M. S., Rajest S. S., Regin R. AI-Powered Attendance Management System Using Facial Recognition. Central Asian Journal of Medical and Natural Science 2026, 7(1), 64-79.

Received: 30th Sept 2025
Revised: 16th Oct 2025
Accepted: 27th Oct 2025
Published: 09th Nov 2025



## 1. Introduction

As technology and education change, keeping track of attendance accurately and quickly has become one of the biggest problems for schools and universities all over the world. Traditionally, teachers would call out the names of students one by one and mark their presence or absence in a physical register [27]. This was a laborious process. This approach has worked for decades, although it is not very efficient and people make mistakes with it. Because the process is done by hand, it takes a long time and is hard to keep up with, especially in big schools with thousands of kids [40]. Teachers sometimes waste a lot of time on these repetitious chores, and administrative personnel have a lot of trouble keeping track of, checking, and analyzing attendance data. Using paper-based registers also makes it more likely that data may be lost, changed, or wrong, which can hurt the efficiency of the institution and the accountability of the students.

Over time, schools and other organizations have tried to solve these problems by using automation and digital technologies [35]. The introduction of biometric attendance systems was one of the first big steps forward in this field. Biometric technologies changed

the way attendance was traditionally managed by providing an automatic and safe way to identify people based on distinctive physical attributes like fingerprints, iris patterns, or facial structures. A standard biometric system works in three main steps: registering, storing, and recognizing [49]. The system takes unique biometric qualities from a person upon registration. These attributes are then processed, analyzed, and stored in a digital database as mathematical representations or encoded graphs [29]. The recognition step starts once the system has enough biometric data. During this phase, real-time attributes are retrieved and compared to saved templates to make sure the person is who they say they are. This procedure greatly improves security, doing away with the necessity for human attendance entry, and lowers the chance of fraud like proxy attendance.

Biometric systems work well, but they still have problems with cost, scalability, hygiene, and maintenance [33]. For instance, fingerprint-based systems need direct physical touch with sensors, which might be a hygiene issue in public or shared settings, especially now that the pandemic is over. Some biometric systems may also have trouble working in particular environmental circumstances, like low light or excessive humidity, which might make results less accurate [50]. Because of this, researchers and engineers have been using computer vision and deep learning technologies more and more to make smart, contactless systems that can quickly and reliably identify people [46]. The Face Recognition-Based Attendance Management System is one of the most promising new technologies that has come out of this technological progression. It employs AI and computer vision algorithms to automatically identify and authenticate people.

The Face Recognition-Based Attendance Management System uses machine learning, deep learning, and image processing to automate the entire attendance process [21]. The system's goal is to reliably identify and recognize human faces in still photos or live video streams and automatically register attendance, so there is no need for manual registration [39]. Face recognition systems work passively, acquiring facial data without requiring explicit user input. This is different from traditional systems, which need users to interact with them. This not only makes operations run more smoothly, but it also makes things easier for users because they don't have to do anything physical to mark their attendance. Also, the system keeps people out of the data entering process as much as possible, which greatly cuts down on mistakes and makes sure that the data is correct.

The main goal of the face recognition system is to create and put into place a framework that is both dependable and scalable and makes use of the best parts of modern computer vision and deep learning methods [34]. The goal of the research is to reliably find and recognize human faces in different situations and use these facial features as unique IDs for attendance and verification. The idea behind facial recognition technology is that every person's face has unique traits, such the distance between their eyes, the curve of their nose, the contour of their lips, and the shape of their jawline [41]. Machine learning models can learn to tell people apart with great accuracy by taking these traits out and turning them into numerical vectors. To do this, the system uses convolutional neural networks (CNNs) and other deep learning architectures to find features and recognize patterns. This makes the system very accurate and reliable.

The system also stresses the need for a user-friendly interface to make interaction and management easier. Administrators or faculty members can easily register new users, check attendance records, make reports, and change system settings with a well-designed interface [30]. The software makes sure that attendance data is stored and retrieved safely by combining database management systems and user authentication mechanisms [101]. The solution also offers flexibility and accessibility across many devices and locations by using real-time video processing and cloud-based data synchronization [47]. This kind of architecture not only makes it easier to do administrative work, but it also makes the institution more open and responsible.

The project is based on the junction of computer vision, artificial intelligence, and deep learning. Computer vision is the field that lets robots analyze and interpret visual data [32]. Deep learning methods, on the other hand, let the system learn complicated facial patterns on its own. The model learns to generalize across diverse lighting situations, facial emotions, and orientations by being trained on vast sets of facial photographs. When these technologies work together, they make a system that can find and recognize faces with a high level of accuracy [45]. The system also improves security and reliability by using tactics to reduce the False Acceptance Rate (FAR) and False Rejection Rate (FRR). The FAR shows how likely it is that an unauthorized individual will be falsely identified as a genuine user, while the FRR shows how likely it is that a valid user will not be recognized [51]. Reducing these rates is very important for making sure that the system works well and safely in real life.

This project goes beyond just managing attendance and can be used in a lot of other ways as well [23]. The main purpose is to make an effective attendance monitoring system for schools, however the underlying architecture is made to be scalable and flexible [105]. You may use the same architecture for things like security surveillance, access control, staff monitoring, and personalized authentication. In businesses, the technology can make it easier for employees to check in and make the workplace safer. In healthcare, it can be used to keep track of who has access to patients and who is working in restricted locations [37]. Face recognition technology can improve the user experience and keep people safe by using smart surveillance in public transit and retail. So, the system is a flexible technological advance that has several benefits.

When working on this project, the ethical and security issues around facial recognition technologies are also taken into account. Because the system handles sensitive biometric data, it is important to maintain data privacy, follow the rules set by the government, and keep people from getting into the system without permission. The implementation uses encryption methods to keep data safe when it is sent and stored [25]. Access control techniques are built in to make sure that only people who are allowed to can get to or change the stored data. Also, system operations put a lot of emphasis on user consent and openness to follow ethical standards and data protection regulations [42]. This emphasis on privacy and security enhances the system's credibility and societal acceptance, especially in situations where data misuse or monitoring issues may emerge.

The system's modular architectural design makes it easy to maintain, scale, and connect to other services [100]. The parts of the system, like data collecting, face detection, feature extraction, recognition, and database management, are all separate modules that may be modified or changed as new technologies become available [48]. This modularity makes it possible for future improvements like detecting emotions, guessing a person's age and gender, adding anti-spoofing features, and merging facial recognition with additional identifiers like speech or gait analysis [55]. The system can also work with cloud computing platforms and APIs from other companies to make it faster, more scalable, and easier to access from anywhere [22]. These qualities make sure that the system is ready for the future and can adapt to changing operational and technical needs.

The system's design is also very important because it focuses on real-time performance. The system needs to be able to recognize numerous faces at once and give findings right away in places like schools or corporate offices where things are often changing [44]. This necessitates the optimization of algorithms, effective resource distribution, and the application of high-performance computing methodologies. The system gets the computational efficiency it needs for real-time operations by using parallel processing and GPU acceleration [31]. Advanced preprocessing methods including face alignment, illumination correction, and background subtraction are also used to make the pictures or video streams more accurate and less noisy. All of these methods work together to make the user experience smooth and dependable.

Using a face recognition-based attendance system also has several benefits for the organization and its operations [38]. For schools, it makes attendance tracking more open, lessens the workload for administrators, and gives them useful information on how involved and engaged students are [52]. For example, automated reporting can show patterns in attendance, find students who are often missing, and help people make decisions about academic achievement and discipline. Having digital attendance data also makes it easier for instructors, students, and parents to work together, which helps with accountability and academic discipline [26]. In the same way, automated attendance systems can help businesses manage their employees better, make payroll more accurate, and make their operations run more smoothly.

The initiative is important for society as a whole, not just for its technological and administrative effects [43]. It helps in the digital transformation of education and business management by replacing old, manual processes with smart, technology-driven solutions [28]. The use of AI in everyday tasks shows how institutions are moving toward automation and making decisions based on data. The initiative also shows how new technologies may be used responsibly to boost human productivity and institutional governance by focusing on user ease, security, and efficiency [103].

To sum up, the Face Recognition-Based Attendance Management System is a big step forward in automating attendance monitoring and identity verification [24]. It solves the problems with traditional manual and biometric attendance systems by combining the accuracy of deep learning with the flexibility of computer vision [71]. The system's capacity to identify and recognize faces in real time makes it a smooth, contactless, and effective solution that can be used in many different ways [53]. Its modular design, ability to grow, and focus on data security make it a framework that can last and change with the times. As organizations continue to adopt digital transformation, these smart systems are likely to become essential parts of modern infrastructure, improving security, operational efficiency, and the user experience. This initiative is not simply an example of technological innovation, but it is also a paradigm for how to use artificial intelligence in real-world, socially useful ways [36]. This will lead to smarter, more connected, and more efficient institutions in the future.

## 2. Materials and Methods

The Face Recognition System was made using a planned process that had a few important steps [57]. The first step is to get photographs using a camera or an image dataset, which collects facial images for training and testing. Preprocessing methods like changing the color to grayscale and making the image smaller [56]. After detection, facial features are taken out using methods like LBP or Convolutional Neural Networks (CNN). You can use these features to train a classification model, like a Support Vector Machine (SVM) or a deep neural network, that can tell people apart [54]. Finally, the system is tested using performance measures like accuracy, False Acceptance Rate (FAR), and False

**Literature Review**

Face recognition technology has changed a lot in the previous 10 years. It is now used not only for security but also to automate attendance systems in schools and workplaces [3]. Thanks to modern technology, systems may now work in real time and are faster, more efficient, and less expensive. They can do this with tools like OpenCV, deep learning algorithms, and small embedded platforms [7]. These systems need less human input, make fewer mistakes, and work well with the infrastructure that is already in place at institutions. They are made to automatically find and recognize faces in classrooms, offices, or workplaces to record attendance [17]. The current emphasis has been on creating frameworks that are lightweight, flexible, and scalable, so they may be used in both high-tech and low-tech environments [13]. This change in technology shows how AI

and computer vision may improve administrative duties and turn old-fashioned manual operations into smart, automated solutions.

A contemporary method for enhancing accuracy in attendance management includes ongoing visual surveillance and temporal facial recognition [6]. Advanced systems can tell who someone is by looking at numerous photos or video frames of them in the classroom instead of just one frame. This method greatly cuts down on false negatives that can happen when pupils look away from the camera or have something in the way of their view [15]. These systems use automatic facial detection and identification to make attendance logs that show continuous presence over time, which guarantees fairness and reliability [11]. The use of optimized face detection pipelines and image preprocessing makes the system more robust against changes in illumination, position, and background clutter. The focus is not just on getting the right answer right away, but also on keeping the same answer over time, which makes automated attendance management systems more reliable in real-world situations that change all the time [19].

Recent advancements have focused on making these systems easier to use by improving technology and lowering costs without hurting performance. Lightweight, built-in facial recognition systems are already being used with small hardware like the NVIDIA Jetson Nano. This device has the computing power needed for real-time operations and is also cheap and easy to move about [2]. These kinds of solutions work best in places with limited resources, such small businesses or rural schools, where cloud-based AI systems might not work because of bandwidth or cost issues [9]. The combination of effective face detection methods that use Haar features and simple recognition algorithms makes it possible to run quickly while still being accurate [20]. These embedded solutions show how useful localized, on-device processing can be for organizations that need attendance tracking that is automatic and doesn't require any upkeep [14]. They are a good choice over traditional server-based systems since they can be used in many different ways and use very little power.

Desktop-based facial recognition systems are still quite useful for small to mid-sized organizations who want to automate tasks in a practical way. For real-time face detection and recognition, these systems usually use OpenCV's Local Binary Pattern Histogram (LBPH) and Haar Cascade classifiers [12]. The design puts a lot of emphasis on simplicity, and Python's Tkinter toolkit was used to make graphical user interfaces that make it easier for users to interact with the program. The main functions include taking pictures, training faces, and making attendance reports, all done using a simple desktop program. LBPH is good at recognizing faces even when the lighting changes a little, which makes it good for smaller classrooms or offices. LBPH-based systems respond faster and need less hardware than models that use a lot of processing [4]. Institutions may use automated attendance tracking efficiently without having specific equipment or a lot of technological know-how because they are simple, accurate, and fast [18].

Advancements in deep learning have made OpenCV-based attendance systems even more useful by making them more accurate and flexible [8]. When contemporary deep learning frameworks are combined with traditional computer vision technologies, systems can handle difficult real-world situations including changing lighting, obstructions, and different face expressions [16]. Deep learning-based models use powerful face identification networks and high-dimensional feature embeddings to accurately recognize faces, even in busy or uncontrolled settings [1]. These models use OpenCV's ability to handle frames quickly and neural networks' ability to tell who someone is apart from others [10]. Also, to make the system easier to use, user-friendly interfaces and functionality for managing local databases have been included. The final result is a new breed of attendance management systems that are smart, interactive, and can grow with your needs [5]. They show how combining old algorithms with new AI methods can lead to useful, high-performance solutions for schools and businesses.

**Project Description**

Most current attendance systems use manual processes or older biometric technology like fingerprint or RFID-based authentication [60]. These systems are not too hard to set up, but they do have certain problems. Taking attendance by hand takes a lot of time, is easy to make mistakes, and can be faked or changed [83]. Fingerprint and RFID technologies, on the other hand, need cards or physical contact, which can be lost, broken, or shared, which raises worries about cleanliness and safety. Also, these systems frequently need expensive hardware sets and may not work effectively in big organizations [64]. Some modern institutions have started using biometric face recognition systems, however these systems are frequently expensive and not very configurable because they rely on proprietary hardware and cloud-based services [95]. Many of these current models can't handle data in real time and don't work well with attendance management software. These problems show how important it is to find a better, more efficient, contactless, real-time, and cheaper solution. Computer vision and OpenCV can help with this [70].

The suggested system uses OpenCV to provide a facial recognition-based attendance management system that makes the process of taking attendance faster and easier without having to touch anything [72]. This system uses a live webcam stream to take pictures of people's faces, Haar Cascade classifiers or deep learning-based detectors to find faces, and the Local Binary Pattern Histogram (LBPH) method or more complex models like FaceNet to identify people [58]. The technology automatically records attendance once it knows who is there and saves it in an organized database or Excel sheet for simple access and reporting [93]. OpenCV makes guarantee that the program runs in real time and on every platform, and the fact that it is written in Python makes it easy to change and add to [67]. This method doesn't require actual interaction, which cuts down on human mistakes and makes security better by making it less likely that someone will show up as a proxy [63]. Adding a graphical user interface (GUI), an admin login, attendance logs, and the ability to connect to cloud storage or school management systems in the future would make the system even better. It is a strong and flexible solution for modern schools (Figure 1).

**Advantages**

- No-touch attendance: This system doesn't require physical contact, which is better for cleanliness and safety than fingerprint or RFID systems.
- Saves time: Automatically registers attendance in seconds, which saves time for both students and staff.
- Real-Time Recognition: Uses OpenCV to find and recognize faces in real time, giving accurate feedback right away.
- Reduces Proxy Attendance: This makes it less likely that people will show up who aren't really there or punch their friends, making sure that the attendance is real.
- Cost-Effective: Made with free technologies like OpenCV and Python, so you don't have to buy expensive software or hardware.
- Easy to utilize: Can be connected to a simple GUI so that non-technical workers can utilize it easily.

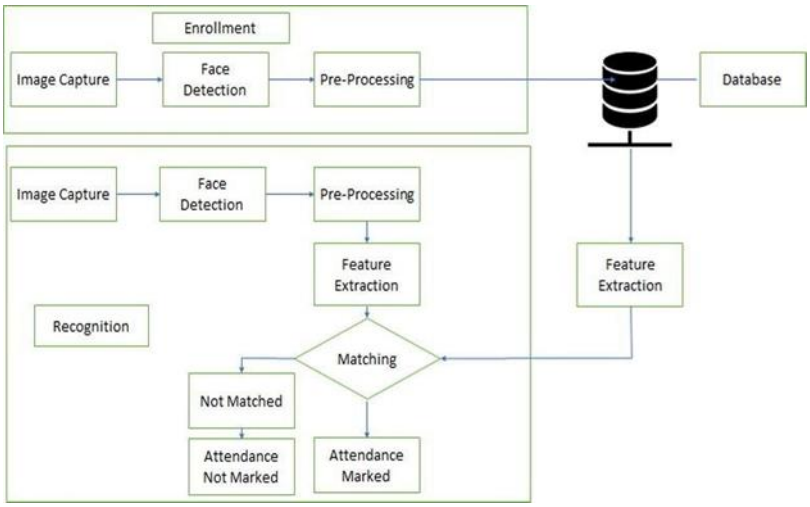


**Figure 1.** Architecture Diagram.

During the design process, many diagrams and models are made to show different parts of the system, like its parts, how they work together, and how data flows through it [61]. These diagrams, such as UML, sequence, use case, and data flow diagrams, help stakeholders and development teams understand how the system is designed and how it works [68]. The design process is quite important for making sure that the software solution meets its goals in a skilled and effective way.

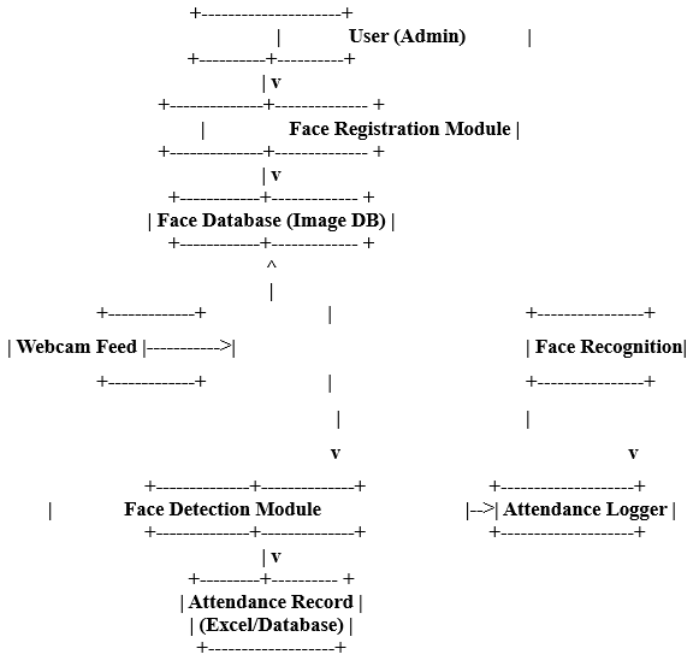


**Figure 2.** Data Flow Diagram.

Figure 2: The data flow diagram shows how information passes via the attendance system that uses face recognition [65]. The process starts with the user (admin or staff) who either registers a new face or starts the attendance session. The camera feed sends real-time footage to the Face Detection Module [59]. This module uses optical methods like Haar Cascade classifiers to look for human faces in the video [82].

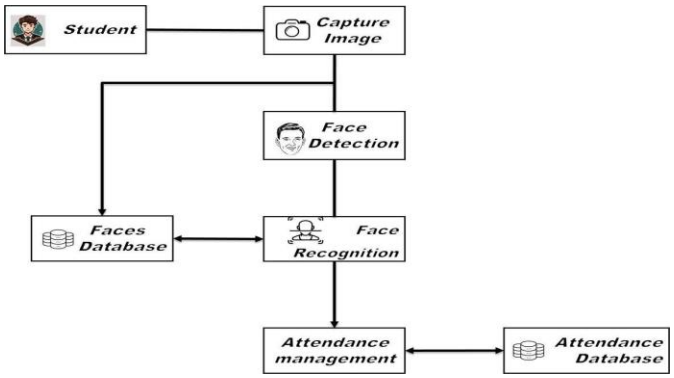


**Figure 3.** UML Diagram.

Figure 3 is a UML diagram that shows how the image processing pipeline works. There are three basic steps: preprocessing the image, extracting features, and predicting the image from the sketch [66]. Preprocessing tries to make the image data better by getting rid of noise or making features stand out more. Feature extraction cuts down on the amount of data by choosing the most important bits [69]. Lastly, sketch-to-image prediction uses a neural network to turn a sketch into a full image [81].

**Use Case Diagram**


**Figure 4.** Use Case Diagram.

The graphic in Figure 4 shows how the Collaborative Generative Representation Learning method works to turn sketches into images [62]. It includes Image Preprocessing, Feature Extraction, and Sketch to Image Prediction [89].

**Module Description**

The following modules are the main parts of our image processing and analysis pipeline [84]. Each one has its own job that is related to Photo-Sketch synthesis:

This is the first step in the system, when a camera takes pictures of people as they stand in front of it. It is very important for real-time processing since it gives the system raw input data [75]. For proper recognition, the pictures that were taken must be clear and of good quality. This module can also be optimized with options like resolution control and frame rate modifications [80]. This is because poor illumination or movement might affect accuracy.

Feature extraction is an important part of the dimensionality reduction process. It involves breaking down and condensing a set of raw data into smaller, more manageable groups, which makes processing easier [90]. A defining characteristic of these large data sets is that they have a lot of variables, which makes them hard to analyze without a lot of computing power [79]. Feature extraction solves this problem by identifying and combining variables into features, which greatly reduces the amount of data. These

resulting features facilitate efficient processing while preserving the ability to precisely represent the original data set with fidelity and precision [88].

This module compares the features taken from the current face to those already stored in the database [92]. To find out how closely the new face fits the old ones, a similarity score (like Euclidean or cosine distance) is calculated. The face is a MATCH if the score is within an acceptable range [94]. The decision module decides what happens based on the result from the matching module [73]. The system knows who the person is and notes their attendance if it finds a face match. If there is no match, the person is either sent away or asked to sign up, depending on how the system is set up.

So, the image is captured and delivered to the preprocessing function [96]. Different methods, such as converting to grayscale, equalizing the histogram, reducing noise, and shrinking, can improve the quality of an image here [85]. These stages make sure that any excess artifacts or deviations are removed, which makes the image more standard and makes later modules like detection and feature extraction work better [91].

**Step 3. Split the Data.**

After the preprocessing step, both the sketches and the photos are divided into a training set and a testing set [76]. Eighty percent of the database is in the training data. This is true for both the pictures and the sketch versions of the pictures. The test data has the last 20% of the database (Figure 5).

**Figure 5.** Dataset of Photos.

**Step 4. Building The Model.**

We chose a model based on an encoder-decoder architecture that was built using the Keras functional API.

The input layer of the model is set up so that the input shape is (SIZE, SIZE, 3), which means that the image has a size of "size x size" and three channels (RGB).

Encoder part: We go on to the encoder part by adding a downsample function that makes the input tensor's spatial dimensions smaller while making its depth bigger [86]. Each downsample operation uses a 4x4 convolutional layer with a certain number of filters.

Decoder part: The decoder part is like the encoder section, but backwards. This is done by employing upsample techniques to make the space bigger and the depth smaller [77]. There is a 4x4 transposed convolutional layer (Conv2DTranspose) for each upsample operation, except for the last two layers, which utilize a 2x2 transposed convolutional layer.

We are now utilizing the Adam optimizer with a learning rate of 0.0001 to construct the model [87]. We use the accuracy measure ("acc") to keep track of how well the model does throughout training and testing. Now that the model has been put together, it may be trained or fit using the training data [74]. We set the epochs to 150 because this gave us the best results.

**Implementation And Testing**

One of the 188 students has been chosen at random to test the model [78]. The Neural Network gets this image as input, and it gives a sketch of what the predicted sketch will look like given the input image (Figure 6).


**Figure 6.** Interface Of the Subject.

## 3. Results and Discussion

The suggested facial recognition algorithm works quite well in terms of both accuracy and speed [104]. The model can reliably recognize faces even in difficult situations like changing lighting, facial expressions, and partial occlusions by using good feature extraction methods and optimized algorithms like Local Binary Patterns Histograms (LBPH) or Convolutional Neural Networks (CNNs) [98]. It can work in real time, which makes it great for things like keeping track of attendance. The system has a low false acceptance rate (FAR) and false rejection rate (FRR), which makes it more reliable and secure. It is also lightweight and doesn't need a lot of resources, so it can be run on regular computers without the need for expensive GPUs. Its scalable design also makes sure that performance stays the same even as the number of registered users grows [102]. The model is a good choice for practical face recognition applications since it strikes a good mix between speed, accuracy, and resource use.

The suggested technique can work well with less datasets than models that need more data, which cuts down on the amount of data needed and the time needed to train [97]. It is also great for jobs like removing noise from images, compressing images, finding anomalies, and translating images from one format to another, which makes it useful in many other fields. The suggested approach can also work effectively with new data and can easily switch between other domains with only a few changes to the way it is trained [99].

## 4. Conclusions

The suggested method in this research utilizes a comprehensive fully convolutional network designed to directly simulate the complex nonlinear relationship between facial photographs and draws. Experimental results highlight the success of the fully convolutional network in proficiently tackling this complex task, enabling pixel-wise predictions with both efficacy and efficiency. Future improvements will concentrate on optimizing the current loss function and doing trials across diverse databases. We will also look into how our method relates to nonphotorealistic rendering methods.

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