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A REAL-TIME FACE RECOGNITION ATTENDANCE SYSTEM BASED ON KERNEL PRINCIPAL COMPONENT ANALYSIS AND SINGULAR VALUE DECOMPOSITION

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***Abstract*— Attendance is an essential component of every organization. Keeping an attendance register daily is a challenging and time-consuming task. There are numerous automated ways available such as Biometrics, Eye Detection, Speech Recognition, etc. for human verifications. This paper outlines a simple and effective way for tracking attendance. Face recognition provides an accurate system that solves ambiguities such as fraudulent attendance, excessive cost, and time consumption. For facial identification and attendance storage, this system employs a face recognition library in Open CV (Python). The camera captures the image and sends it to a database folder containing images, which identify faces and calculate attendance. The goal of creating this automated attendance system utilizing Artificial Intelligence was to reduce the errors that occur in the traditional attendance-taking system. A face recognition system has been presented that has robustness toward user recognition and the result is transformed into an Excel Sheet in Real-Time.**

***Keywords*— Face Recognition, Open CV, Numpy, DLIB, Cmake, Face Detections.**

I. INTRODUCTION

As humans, our minds are built to do all of this naturally and rapidly, but Computers are incapable of this order of accuracy, as each stage of face recognition must be taught or programmed independently. Pattern recognition is the process by which a machine can recognize and discern a pattern from perceptual input based on its surroundings, and make reasonable and acceptable classification decisions. Typically, facial recognition does use a large database of photos to determine a person's identity; rather, it simply identifies and recognizes one person as the device's sole owner, while denying access to others. The technologies employed include statistical, probability, computational geometry, and algorithm design. Understanding how patterns are represented and recognized in nature has a big impact on building a pattern recognition system. Face detection and Face recognition are one of the major biometric categories. Generally, this facial detection and facial recognition reduce the amount of physical labor required by humans. Images are taken via the camera, and face detection techniques are used. In photographs, we usually observe the nose, hair, ears, lips, and eyes, as well as varied poses of faces.[1] It is possible to conclude that no single biometric is ideal. When we consider facial recognition, it appears to be a better strategy. It has the significant advantage of being the only biometric capable of identifying people at a distance without subject complicity or awareness. It is also a useful technique for people who have difficulty touching the sensors, such as in fingerprint recognition.[2] It cannot injure any physical portion of the body.

According to the Previous Studies, there are a variety of application sectors where it plays an important function.[3] Face biometrics are measured using a variety of face recognition technologies. Security systems, authentication, access control, surveillance systems, smartphone unlocking, and social networking services all make excellent use of facial recognition. Face recognition, unlike fingerprinting or other security measures does not require any physical contact, making it a quick, automatic, and seamless verification experience in the post-COVID era.[4] Businesses require both secure and fast technologies in an era of cyber-attacks and advanced hacking tools. Facial recognition allows you to verify someone's identity quickly and easily. Security software and facial recognition software are generally compatible. It's

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actually quite simple to set up. This reduces the amount of money required to set it up. As technology and algorithms progress, facial recognition systems have the potential to replace traditional passwords and fingerprint scanners.[5] They concern access control, entertainment, and database encryption. Some of the individual areas are highlighted below:

1. Information Safety.
2. System of Criminal Justice.
3. Multimedia settings.
4. Gender categorization.
5. Facial expressions.
6. Reconstruction of the witness's face.

II. LITERATURE REVIEW

Kunjal et. al. [1] has characterized it as a collection of features of an item under examination, as well as the right class information for that object. A sample pattern of an item is sometimes known as an instance of an exemplar. A pattern recognition system's purpose is to predict the proper label for a given feature vector based on past information gathered via training.

Sunaryono et. al. [2] has used Haar's Feature-based Cascade method. The image depicted is obtained using the Histogram of Oriented Gradients (HOG) are compared to one another. The servo motor is connected to the operating system to facilitate the opening of a prototype door. To enter the class, you must be a recognized student.

Bhandare et. al. [3] has studied a face expression detection system employing a unique local Gabor filter bank. It selects and compresses the Gabor feature using a two-stage feature compression approach Principal Component Analysis + Linear Discriminant Analysis then uses a minimal distance classifier to identify face emotion. It uses Scale Invariant Feature Transform (SHIFT) for feature detection. Experiments show that the approach is beneficial for both image reduction and strong recognition performance when compared to the standard complete Gabor filter bank.

Siswantoro et. al. [4] has introduced an ear-based technique. These retrieved characteristics are saved in a database. Each vector is saved in the database and refers to a specific image. The feature vector of the test image is compared with the entries in the vector database for the purposes of developing and managing a database, individual records, and featured vectors. The Open FOAM Drivers are used for data comparison and decision-making, as well as a data connection.

Zhi-heng et.al. [5] has made feature vectors constructed from face points convolved with Gabor filters, as well as complete image pixel representations of static facial images, which were evaluated by the author of the research paper. These feature vectors were subjected to PCA, and classification accuracies were compared using LDA. Experiments in two databases show that the Gabor filters perform similarly, with a classification accuracy of 75 percent. This was accomplished using low-resolution photos, and there was no need to precisely pinpoint facial points on each image.

Shervin et. al. [6] has Higher-order relationships and nonlinear principal components that can be created by using polynomial functions. (Gas)Genetic Algorithms are used to determine the feature set for classification after getting nonlinear principal components. The linear Support Vector Machine was used as a classifier for the recognition tasks during the recognition stage. The method was tested using two face databases, and greater recognition rates were achieved, demonstrating that the approach is successful.

VenkataKalyan et. al. [7] has proposed a hybrid technique based on the Support Vector Machine for categorizing facial gestures into 6 main emotional responses. The Gabor filter lender is given as input pictures first. The filters are then subjected to the PCA feature extractor. Finally (SVM) Support Vector Machine and Laplacian Image Quality Evaluator is obtained to classify data. The results of the suggested method are compared to those of one of the combined PCA and SVM classifiers. The results of the experiment show that the proposed strategy is effective. The average recognition rate in this study is 89.9%, which is higher than 87.3 percent.

Bhattacharya et. al. [8] has recommended increasing the rate of facial recognition. U-face is a normalization model for facial recognition. U-face eliminates backdrop, hair, and other elements that interfere with face identification, leaving only the emphasis on the facial region. PCA then describes the facial recognition algorithm. The results of using PCA and facial recognition algorithms on a U-face simulation indicate that the U-face improves recognition rates.

Rajesh et.al. [9] has suggested a new approach that incorporates fingerprint recognition. Initially, the Poincare index approach is used to locate the Core point. The diffusion coherence approach is used to identify and enhance the dominating fingerprint region around the core point. Finally, for the detection of unknown fingerprint pictures, the Average Image Noise Removal classifier is used. The experimental findings show that the algorithm's performance has improved.

Alizadeh et.al. [10] proposed a facing method for a real-time surveillance system that uses four directional features (FDF).FDF is one of the most reliable features for identifying patterns. The FDF includes the input image's four directional features (vertical, horizontal, and both diagonals). It achieved a detection performance of approximately over 10 frames per second, but it still needs a lot of work.

Jitendar et.al.[11] proposed a facing method for a real-time surveillance system that uses (FBPH) Local Binary Pattern Histogram. It is one of the most reliable features for identifying patterns, which includes the input image's four directional features (vertical, horizontal, and both diagonals). It achieved a detection performance of approximately over 10 frames per second, but it still needs a lot of work.

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Table 1: The table shows the Simulation Environment and Simulation Parameters in the previous studies.

Reference No.	Simulation Environment	Simulation Parameter Computed	Contribution
1	Repast	Histogram of Oriented Gradients (HOG Method)	Solve Face Expression Issue
2	UrbanSim	Histogram of Oriented Gradients (HOG Method)	Solve Face Expression Issue
3	DX Studio	Scale Invariant Feature Transform (SHIFT)	Solve Aging Issue
4	Open FOAM	Oriented Fast and Rotated Brief (ORB)	Solve Aging Issue
5	QCAD	Sobel-X Feldman Operator	Solve Time and Space Complexity
6	Free Fem++ (FEA)	Sobel-Y Feldman Operator	Solve Time and Space Complexity
7	Aren, Matlab	Laplacian Image Quality Evaluator (LIQE)	Solve Occlusion Issue
8	Scilab, Matlab	Canny Image Quality Evaluator (CIQE)	Solve Occlusion Issue
9	Simulink, Matlab	Average Image Noise Removal (AINR)	Solve Image Noise Issue
10	GNU Octave, Matlab	Gaussian Image Noise Removal (GINR)	Solve Image Noise Issue
11	OpenCV, Python	Bilateral Image Noise Removal (BINR)	Solve Image Noise Issue

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III. RESEARCH GAPS

1) Previous work may have been lacking in occlusion qualities in face images, making it difficult for the algorithm to work correctly.
2) Different photos of the same individual are being gathered with different positions, emotions, and lighting, which greatly increases Space Complexity.
3) In previous systems, aging had a strong influence, and it is a serious negative for image processing systems.
4) Image noise is not properly eliminated for older photos.

IV. PROBLEM FORMULATION

According to previous studies, the most difficult strategy is making sure the accuracy of the data is acquired. If enforcement is implemented, the company may end up wasting a lot of money. For a single person, an extremely large database of photos is required, which greatly increases the space complexity. Another issue is that the system has advanced to the point where it is excessively time-consuming. As a result, the system has to improve productivity, data perfection, anti-aging, and occlusion. All of the challenges are solved in this approach.

V. METHODOLOGY

Kernel Principal Component Analysis: It is a type of principal component analysis in machine learning in which we employ kernel methods to perform principal component analysis on nonlinearly separable datasets. Principal Component Analysis is an independent learning approach for minimizing dimensionality. It is a systematic test that uses an adaptive algorithm that helps in the findings of correlated features into a set of sequentially nonstationary features. It's one of the most widely used programs for data analysis and computational modeling. It's a method for reducing differences in a dataset and extracting strong patterns. Image processing, movie recommendation engines, and optimizing load balance in multiple communication channels are examples of real-world PCA applications. Because it is a feature extraction approach, it keeps the important variables while removing the less important ones.

The idea behind KPCA is that by projecting datasets onto a higher dimensional environment, many datasets that aren't linearly separable in their original space can be made linearly separable. The extra dimensions are just basic arithmetic operations on the initial data dimensions. As a result, we project our dataset into higher-dimensional space, and because the features are now linearly separable, we can use PCA on the resulting dataset. The Kernel Principal Component Analysis approach is quite similar to the traditional one, but with a different processing step. However, if the dataset is not linearly separable, the Kernel PCA algorithm must be used. It's similar to PCA except that it employs the kernel tricks to map non-linear features to a higher dimension before extracting the principal components in the same way that PCA does. This is a tool for minimizing data dimensions. It allows us to reduce the data dimension while maintaining as much information as feasible.

1) An API for training and testing the KPCA model that is simple to use.
2) Dimensional reduction, data reconstruction, defect detection, and problem diagnosis are all supported.
3) Kernel functions (Gaussian, Laplacian)
4) Training and test results visualization

Singular Value Decomposition: It is a factorization of that matrix into three matrices in linear algebra. It has some intriguing algorithmic properties and provides useful mathematical and theoretical information about linear transformations. It also has some important data science applications. Linear Algebra is the foundation for Machine Learning algorithms, from basic linear regressions to Deep Neural Networks. The major reason for this is that the collection of data may be represented as a 2-D matrix, with the characteristics represented in the column and the sample data points represented in the row. Matrix operations that employ all of a matrix's values, on the other hand, might be redundant or computationally expensive.

The matrix must be represented in such a way that the most important region of the matrix can be quickly retrieved for subsequent calculations. In this case, the Singular Value Decomposition (SVD) is beneficial. In the field of environmental sciences, this advanced regression technique helps in the resolution of complex problems. This method can also be used to generate significant solutions for smaller numbers of values. These fewer values, however, mask the enormous variability present in the original data. In the geophysical and atmospheric sciences, data reveals large spatial correlations. A Singular Value Decomposition analysis backs up these correlations and produces results for a more compact demonstration. Below is the figure of SVD splits into three Matrix.

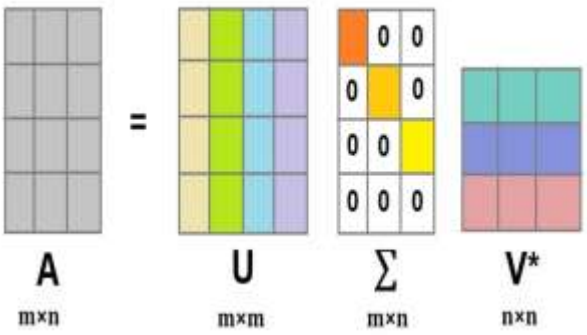

Figure 1: Singular Value Decomposition Matrix.

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VI. PRESENT WORK

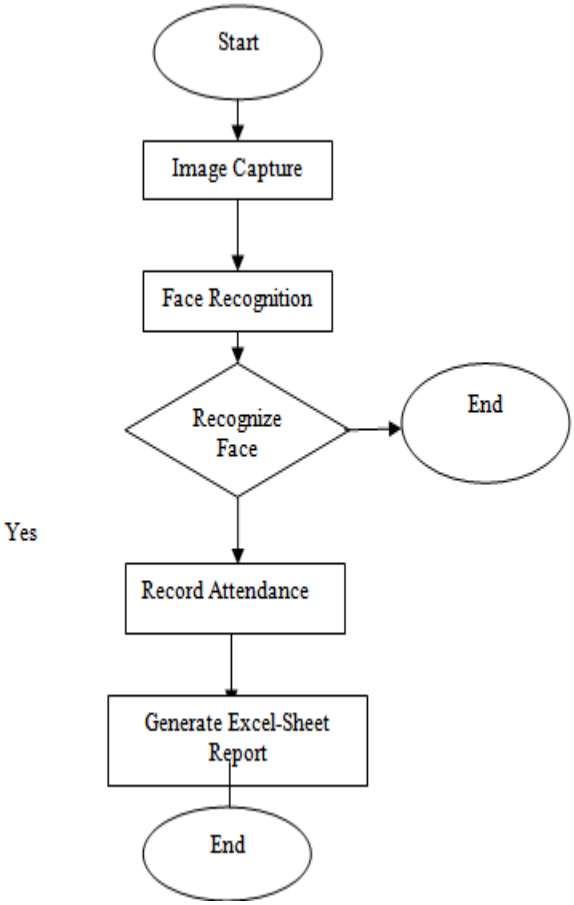

Figure 2: Basic Flow Chart

Step 1: Face Detection**:** The first step in our project is to find all of the faces. We must first locate the faces in a picture before we can try to distinguish them. Face detection is a fantastic camera feature because it automatically selects the faces to ensure that they are all in focus before the photo is taken.

Step 2: Posing and Projecting Faces: We must address the problem that arises when the faces are facing different directions, causing the system to appear completely different. We're now using a technique called "Face Landmark Estimation" because it produces results that are more forgiving than others.

Step 3: Face recognition**:** It is based on a direct comparison of unknown faces to all previously recorded static photos. We only need to take a few measurements from each face at this point. The training process includes the following tasks:

1. Load a known person's face image from data.
2. Get a new picture of the same individual from the data.
3. Insert a photo of a completely different person. After that, we consider an algorithm that examines the measurements.

Step 4: Decoding the person's name**:** In the final stage, all that's left is to find the person in our set of known people who have the most observations of our test image. We're using Linear SVD classifiers for this. Here we train a classifier that can take measurements from a new test image and determine which known individual is the closest match, and then save it as a current state in Excel, indicating that this person is currently in the class. As a result, running this classifier takes milliseconds.

A face recognition system is a biometric software application that compares based on a person's facial characteristics to uniquely identify or verify that person. The term "facial recognition" implies that the software employed for this purpose primarily recognizes a number of distinct facial traits. The feature-based strategy relies on identifying certain fiducial points on the face that are less susceptible to change, such as the points around one's eyes, the sides of one's nose and mouth, and the points around one's cheekbones. The results of the local processing at fiducial sites are then combined to get an overall face recognition result. Because the identification of feature points occurs before the analysis, such a system is robust to variations in image position. The automated detection of fiducial points is insufficiently accurate to provide a high accuracy rate for face recognition.

Hardware Requirements

1. High-Resolution Camera
2. RAM: Minimum 4 GB
3. Processor: Intel i3 or Higher

User Requirements

Machine learning algorithms can be used to solve these challenges by feeding in data and receiving a solution. The following points will help to explain the procedure:

1. First, begin by looking at a photograph and identifying a person who is in the class.
2. Second, focus on each face and determine whether the image is in the correct location.
3. Third, it should be able to recognize distinct facial features that support identifying a person based on these features such as eyes, face, and so on.
4. Finally, the previously saved data is compared to the most recently clicked photo, and attendance is immediately recorded in the Excel sheet in Real-Time.

VII. RESULTS ANALYSIS AND DISCUSSION

First and foremost, we must enter the data into the database for the individual. To do so, we'll need to provide a name for the photo. Now we need to get photos of the person using the webcam or any other cameras accessible, such as the laptop webcam we used here. The information is then saved in the database. To get the findings from the saved database, the camera starts recording and captures an image. It keeps track of attendance in Real-Time on an excel sheet. The proposed model's results are examined in terms of image smoothing, feature detection, and edge detection parameters. These

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parameters are calculated to evaluate the proposed model's performance and to track the simulation's progress.

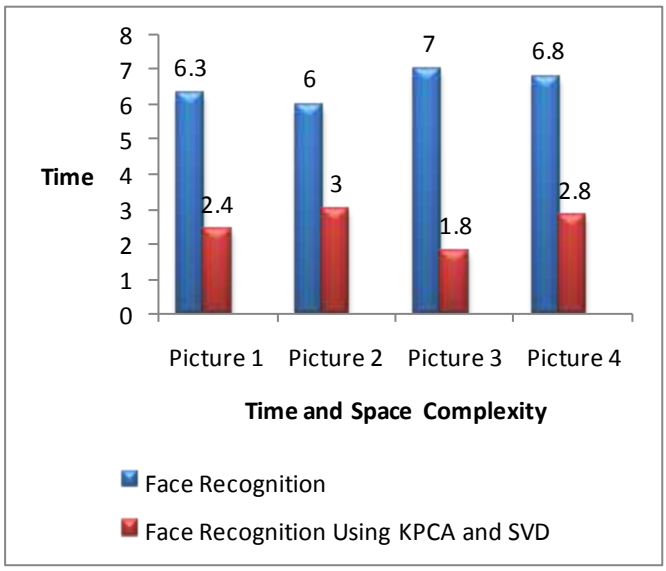

Figure 3: The graph compares the Time and Space Complexity of four images from the previous and improved face recognition systems.

As shown in Figure 3, it takes a huge amount of time to recognize a single face from its database folder, which contains a large number of images of a single person in various poses; additionally, it does not always consider accurate results, which was a major flaw in the previous system. The Sobel Operator is a discrete differentiation operator. It computes the gradient approximation of the image intensity function for image edge detection. At the pixels of an image, the Sobel operator returns either the normal to a vector or the equivalent gradient vector.

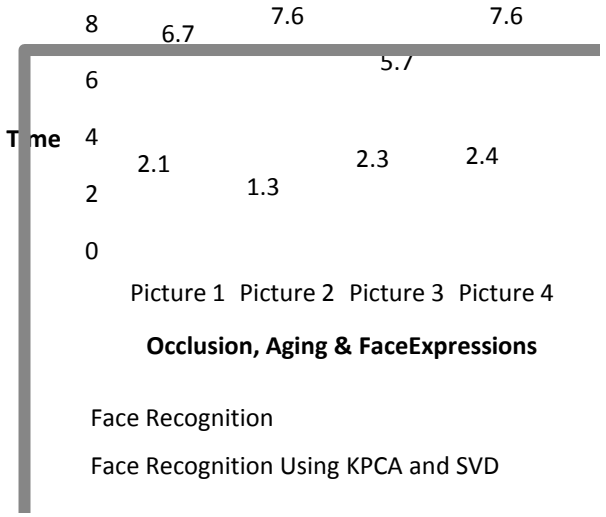

Figure 4: The graph compares the Occlusion, Aging, and Facial Expressions of four images from the previous and improved face recognition systems.

Face recognition using KPCA and SVD had extremely high quality in recognizing faces that were affected by occlusion, aging, and facial expressions, as shown in Figure 4, which is something that previous systems haven't even considered. With the help of edge detection, all of these issues can be resolved. For images with various image attributes, feature detection is applied. Feature detection is a method for computing image layers and determining whether or not each image point contains an image feature of a specific type. Feature detection is a low-level image processing operation. SIFT (Scale Invariant Feature Transform) breaks down a picture into a large number of local feature vectors, each of which can be used for image translation, scaling, and rotation, as well as being partially invariant to changes in illumination and affine or 3D projection. ORB (Oriented Fast and rotated brief) is a hybrid of FAST and BRIEF. As a result, ORB serves as both a detector and a descriptor. ORB's main goal is to cut down on resource consumption. This resolves the issue of image aging. The image is converted to edge detection. Edge detection is an image processing technique for detecting object boundaries within images. It works by detecting brightness changes. In areas like image processing, computer vision, and machine vision, edge detection is used for image segmentation and data extraction. A large shift in the grey level of an image's features can be detected via edge detection. The Laplacian is a 2-D image measure that is isotropic. The Laplacian is applied to an image that has been smoothed with a Gaussian smoothing filter to reduce noise sensitivity.
This operator takes a single grayscale image as input and produces another grayscale image as output. The Laplacian Operator is a derivative operator for finding edges in images. A second-order derivative mask is a Laplacian. A multi-stage edge detector is a Canny filter. The gradient intensity is computed using a filter based on the derivative of a Gaussian.

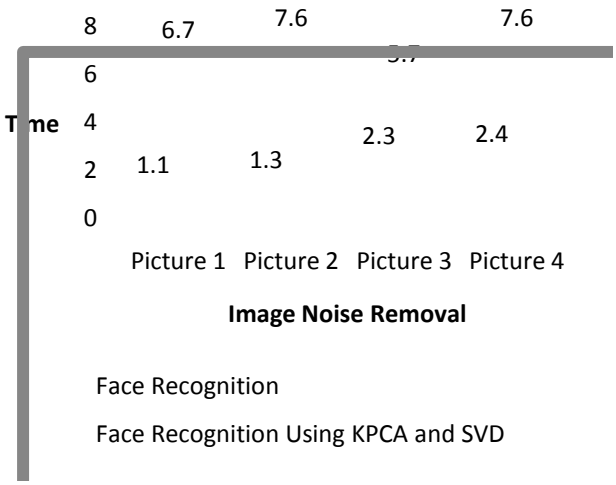

Figure 5: The graph compares the Image Noise Removal of four images from a previous face recognition system with that of a new face recognition system.

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The problem of image noise is regarded as a significant change in the system For example, if we have an old photograph that contains noise such as salt and pepper, we can use various noise removal methods to remove the noise as shown in Figure 5. The image noise is reduced by using the Gaussian filter. Then, by deleting non-maximum pixels of the gradient magnitude, possible edges are reduced to 1-pixel curves. Finally, hysteresis thresholding on the gradient magnitude is used to keep or remove edge pixels. The core element is replaced with the average of all pixels underneath the kernel area using averaging image noise. The width and height of the kernel should be specified. Gaussian Distribution is a statistical noise with a probability density function equal to the normal distribution.

To create this noise, the Image function has a Random Gaussian function added to it. Because it occurs in amplifiers or detectors, it is also known as electronic noise. The median image noise removal method, on the other hand, is a great way to get rid of salt-and-pepper noise from an image. It should have a kernel size that is an odd positive number. However, the removal of bilateral image noise is slower than that of other filters. It makes no difference if pixels have similar intensities. We can greatly reduce image noise by using image noise parameters.

The accuracy of the project is shown in the table below. To determine the accuracy of the recognition system, tests were conducted. In the database folder, ten photographs of different pixels values, heights, and image sizes are taken in order to perform both face recognition tests and improved face recognition systems based on KPCA and SVD. The accuracy percentage is shown in both tables. A positive response occurs when the camera correctly recognizes the person and displays accurate results, while a negative response occurs when the camera fails to recognize the person's face.

Table 2: The performance was tested with ten images of different people, and the accuracy was determined as follows in the Simple Face Recognition System.

S.No	Name	Positive Response	Negative Response	Accuracy
1	Elon Musk	3	7	30
2	Jack Ma	4	6	40
3	Modi	5	5	50
4	Bill Gates	5	5	50
5	Jeff Bezos	3	7	30
6	Messi	3	7	30
7	Ryan Reynolds	4	6	40
8	Virat Kohli	4	6	40
9	Sachin	6	4	60
10	Ronaldo	6	4	60
Total Accuracy				43%

Table 3: The performance was tested with ten images of different people, and the accuracy was determined as follows in Face Recognition Attendance System using KPCA and SVD.

S.No	Name	Positive Response	Negative Response	Accuracy
1	Elon Musk	8	2	80
2	Jack Ma	7	3	70
3	Modi	9	1	90
4	Bill Gates	8	2	80
5	Jeff Bezos	9	1	90
6	Messi	7	3	70
7	Ryan	7	3	70

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	Reynolds			
8	Virat Kohli	6	4	60
9	Sachin	8	2	80
10	Ronaldo	9	1	90
Total Accuracy				78%

When compared to previous face recognition methods, the accuracy of face recognition using KPCA and SVD is very high. An improved face recognition attendance system based on KPCA and SVD is used to solve occlusion problems. Complexity in space and time, aging, facial expressions, and image noise, all of which were major flaws in the previous system, have been resolved in the improved version.

Project Screenshots

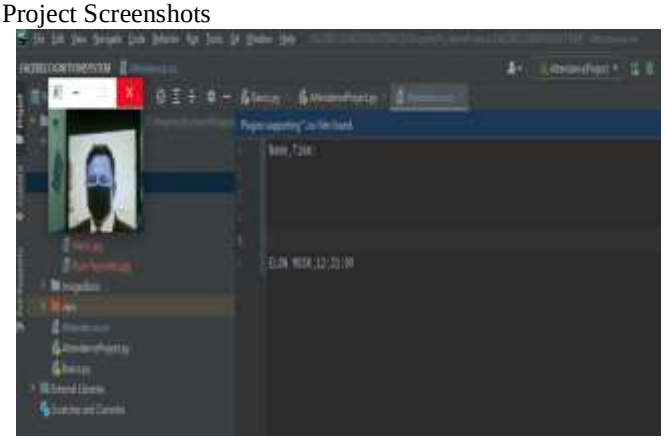

Figure 6: Capturing an image of a person wearing A Mask

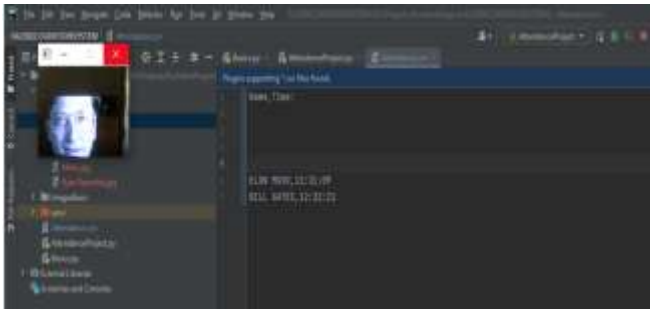

Figure 7: Capturing an image of a person having an Aging Effect

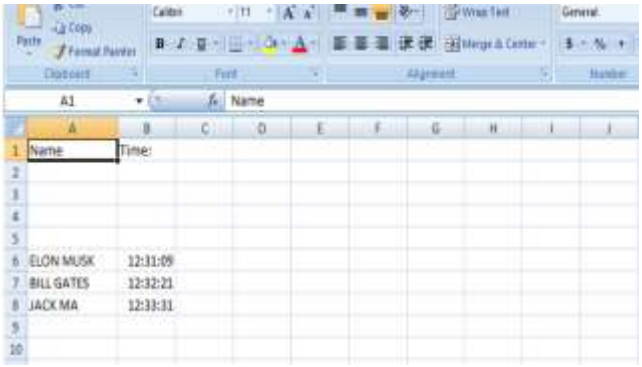

Figure 8: Record the attendance live in an Excel Sheet in Real-Time

All of the above images show the results of the face recognition attendance system using KPCA and SVD. When a person's attendance is recorded in an excel sheet while wearing a Covid Mask, the occlusion effect is shown in Figure 6. Figure 7 shows the aging effect as the person's youth image is taken, and Figure 8 shows the database, which is recorded in an excel sheet with the person's name and time in real-time.

VIII. CONCLUSION & FUTURE SCOPE

The goal is to automate and create a system that will be useful to businesses and educational institutions. One of the few biometric technologies that have received a lot of attention is facial recognition. Authentication, monitoring, access control, indexing, and maintenance are just a few of the applications for facial recognition technology in surveillance. Attendance systems with facial recognition are modern utilities that are required even in the post-pandemic period. These solutions improve employee attendance tracking while lowering expenses. A system like this also provides a degree of protection to the workplace. For monitoring employee hours, facial recognition technologies are the finest current solution. If your company still uses a manual attendance system, it's time to change to a facial recognition attendance system. Face recognition technology has facilitated the advancement of multimedia information access. Furthermore, employing face recognition for network access control makes obtaining a user's password almost impossible for hackers while also increasing the human-computer relationship. This is one of the reasons why facial recognition attendance systems are becoming increasingly popular. It's also a time-saving algorithm because we use KPCA first and then SVD. The

hybrid model improves accuracy. The installation of the system does not necessitate any specific software. The entire function is designed to increase student attention in class while also saving time for the teacher to cover more material in each class hour. These are the new features that have been added to the application to help and support online teaching.

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