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Application of attitude tracking algorithm for face recognition based on OpenCV in the intelligent door lock

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ABSTRACT

In the era of information system authentication is a major problem. Automated embedded systems in today's world have made a lot of progress. The importance of an automated embedded system has proved highly effective in applications such as surveillance and private security. Modern smart door locks are very susceptible to errors and damage, which will reduce security. Almost every intelligent Door lock has a passcode entry or faces recognition outside the door which makes it vulnerable. The paper is intended to provide the user with open source software OpenCV and proposed an Efficient attitude tracking algorithm (EATA). Furthermore, this article aims to ensure that a key lock system that is retro and modern simultaneously offers a certain safety and reliability. The experimental results show that the proposed system is more efficient, consumes less power, and cost-effective.

1. Modern design on the intelligent control system

The modern design of smart homes pays attention to intelligent controls and transforms traditional switches into compact systems. Home automation is one of the developing sectors that can improve people's living conditions. Some of these home automation systems were built for those pursuing sophisticated and luxury house automation solutions, others for the old-age and the disabled. Home automation means the domestic environment that enhances the quality of life of a resident by making the environment versatile, comfortable, healthy and safe.

The security problem represents an important challenge for every person who is away from home. The earlier system allows manual protection, which attackers can break easily. The users will be able to maintain username/password combinations for accessing accounts by this authentication technique. The authentication of passwords often needs strong server protection or anyone can break into the database and read passwords. The process of developing complex passwords and maintaining confidentiality is a tiresome one when the client does not take them seriously. The fingerprint is the basic authentication method and is a unique identification for every person. For their longevity and their unique identity, they are used for a long time as criminals and forensic work not only in identification in the field of security. Fig. 1 shows the face recognition system with the door lock.

The advancement in the development of nano-semiconductors opens up the internet of things. Almost every device can now be connected to WiFi (the Global Wireless Network), Bluetooth, Zigbee and many other wireless technologies, including mobile phones, tablets, watches, cooling systems, and even glass fridges. In the home security system, the old-fashioned key and lock are still commonly used. Urbanization and various types of criminal activities threaten the effectiveness. Governments, colleges, industries and even wider populations have started using the RFID in recent years. The digital RFID chip, however, is an extra user's peripheral and is vulnerable to loss or defective. Here, common handheld devices are used as electronic locks. Moreover, although there are systems for the identification of facial, fingerprint, speech and iris that identify individuals from their biometrics, their accuracy is greatly influenced by the age, accidents, illness or other undesirable conditions that alter these components. Biometric systems need extremely high sensor resolution, which increases the cost and popularity of the device. Therefore, the residential security industry's future growth strategy is to develop a cost-effective, high comfort, high security, and high transmission rate wireless digital door access system

A comprehensive analysis of the OpenCV platform and its built-in libraries has been carried out to produce code that correctly and reliably recognizes the face using the hardware newly and efficiently. Face detection is more difficult as some unpredictable features have an effect on detection efficiency for example glasses and beards. Different types and angles will also detect eyes, which will affect the detection process, create erratic face brightness. Within a home environment, the human body is recognized as an intruder by capturing live video of a Web camera and processing. As the world progresses, people are afraid of the security of their products, knowledge and themselves.

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Fig. 1. Face recognition system with door lock.

In this paper, we propose an Efficient Attitude Tracking Algorithm for face recognition based on OpenCV in the intelligent door lock system. The web-based camera captures the image sequence as soon as the individual switches. The door is opened with the use of face detection software and with the complete identification of the eyes, the single and tiny push button is pressed. Face recognition involves facial image deletion, identification or classification and reduction of features.

This paper decorated as follows: Sections 1 and 2 discussed the previously existing methods. In Section 3 mathematical model of face recognition using an attitude tracking algorithm has been demonstrated. In Section 4 the experimental results and discussion have been illustrated. Finally, Section 4 concludes the research paper.

Wahyudi et al. [1] introduced the intelligent voice-based door access control system utilizing an adaptive network-based fuzzy inference system (ANFIS) for building security. The intelligent system approach is used to build approved people's voice-based models. The proposed system uses specifically adaptive-network-based Fuzzy Inference Systems to distinguish authorized and unauthorized individuals. By using an enrolled user speaking on a microphone connected to the device, access may be allowed. ANFIS will then decide whether to accept or deny the user's claim for identity or likely indicate inadequate confidence and request additional feedback before making the decision.

I. Yugashini et al. [2] suggested the fast based principal component analysis (FBPCA) for automated door accessing systems with face recognition. FBPCA approach which uses, a web camera to identify the captured image and compare it to the object in the database. If the image is an authenticated one, the door will be automatically opened and an SMS will be generated to the user using a GSM modem that has been entered by an unauthorized person. The Eigenfaces methodology has been applied to the system, making the process simpler. The GSM network has designed and tested a cost-effective and SMS-operated home security system. For future efforts, it is possible to focus more on enhancing performance and robustness in both the system of identification and detection.

Sura Mahmood Abdullah et al. [3] initialized the Jaro Winkler String Comparison Algorithm (JWSC) for the design of a secured smart door lock system. The JWSC algorithm is comparing registered password security with each code entered that may include some incorrect or swapped characters. The results show more real-time access capacity encryption. The Jaro Winkler algorithm was used to pair two strings that contain spelling errors and find common matched characters approximations. These algorithm steps were applied in the Java-based Arduino language platform to compare both registered passwords with passwords sent from smartphone devices via Bluetooth, where door actuators are locked/unlocked. Besides, an authentication control threshold value has been set where the W score should not be less than 0.9.

A.D. Deshmukh et al. [4] introduced the Local Binary Pattern Histograms (LBPH) algorithm for face recognition using OpenCV based on IoT for Smart Door. The captured picture is compared with the available database, and if this suits, the access is granted, and the door opens. The device can be identified and remembered in real-time when a bell is turned on. The captured image is then sent to the user via SMTP if the face does not match the captured image. The program will then wait for the user's response with the corresponding email. On the pi of raspberry, the message is identified with IMAP.

Sourav Roy et al. [5] proposed the Haar cascade classifier Algorithm (HCCA) for the design and implementation of the smart door lock system with a face recognition approach utilizing the Linux platform raspberry pi. A Haar Cascade is generally a classifier that is used from the origin to detect the object for which it was equipped. OpenCV is a software library for open-source vision. This library offers many optimized algorithms, including face detection and recognition, which can be used in many areas related to IoT. The LBPH (Lower Binary Pattern histogram), Haar classifier, face recognizer, was used as libraries of our projects. The Haar-like features the edge functions, the line features, and the center round features are used and are classifier inputs.

To overcome these issues, in this paper, An Efficient Attitude Tracking Algorithm has been proposed for face recognition based on OpenCV in the intelligent door lock system. An extensive study was conducted on the OpenCV platform and its integrated libraries in order to generate a code that correctly and reliably recognizes the face by using modern and powerful hardware. The use of unconventional components like stepper motors and drivers in existing models has been avoided and newer and unforeseen facial recognition technologies have been developed as an access point control system using a combination of a relay unit with a solenoid to open the gate and a special and interactive user interface. We have also used a USB attachable HD Webcam to render efficient and reliable face recognition rather than using a low-quality Raspberry Pi Interfaced Camera.

2. The efficient attitude tracking algorithm

In this paper, we propose an Efficient Attitude tracking algorithm for face recognition based on OpenCV in the intelligent door lock system. This research proposes an idea of a framework for facial reorganizing access to the door lock system that is implemented using the popular computer vision library OpenCV. Due to the use in many fields, face recognition is an important feature of image processing. The project creates an active face recognition system based on OpenCV. The best choice for the biometrics issue was face recognition and it has a range of applications in our lives today. An effective facial recognition system can be of great assistance in forensic science, identification of law enforcement, banking, and safety monitoring and preferential access to authorized users, such as access control for protected areas and so on. A door locking system for real-time facial recognition. When a known person enters the room, the device recognizes the face and opens or closes the door. No special equipment is needed for an object identification system because it can be used on existing image capture devices (webcams, security cameras, etc.). The first step in recognition of the face of human beings is to eliminate the relevant elements from face pictures. Fig. 2 shows the flow chart of the face recognition process.

A. Face recognition using an Efficient attitude tracking algorithm (EATA)

Face recognition is a process with many under-problems. Some systems simultaneously detect and locate faces, others perform a detection routine and try to locate their faces if positive. The attitude tracking algorithm is suitable for the face recognition process.

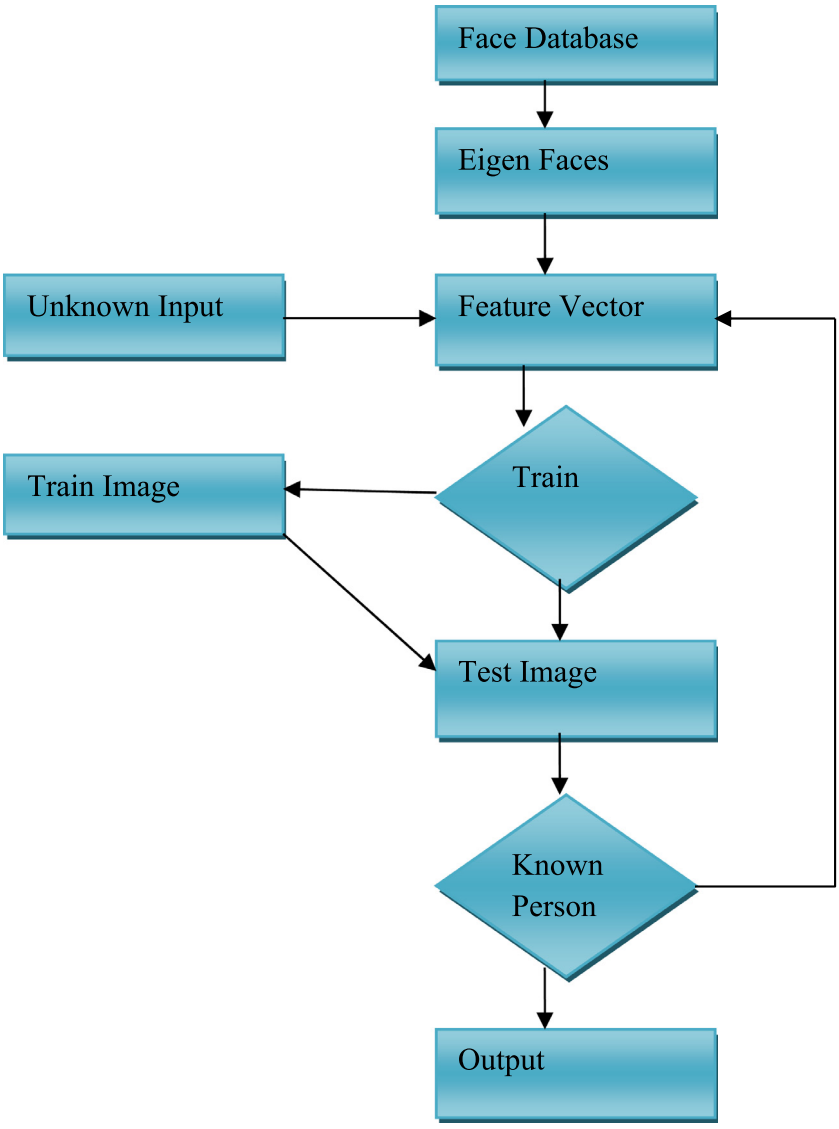

Fig. 2. Face recognition flow chart.

Proposition 1. *Attitude tracking algorithms are required to show the facial structure and human skin color. The best color template to detect faces is very important. Many recent inquiries employ more than one color design. RGB and HSV are used effectively together, for example.*

$$0.43 \le 0.61, 0.224 \le g \le 0.334, r > g > (1-r)/2 \tag{1}$$

$$0 \le H \le 0.21, 0.33 \le S \le 0.73, 0.221 \le V \le 0.84 \tag{2}$$

When light conditions change, skin color can vary significantly. Skin color identification also uses other techniques, such as regional symmetry and structure and geometry, in conjunction.

A probabilistic approach is used to construct Haar cascade classifiers. The rule of the decision of Bayes is commonly used. The rule can be changed to take into account various factors that may contribute to mismanagement. Bayesian decision rules can provide an ideal classification, and the Bayes error can be the best criterion for determining features. A posteriori probability function can, therefore, be optimal.

$$q(Y \mid \varphi_j) Q\left(\varphi_j\right) = \max\{q(Y \mid \varphi_j) Q(\varphi_j)\}\, Y \in \varphi_j \tag{3}$$

As shown in Eq. (3) φ_j is face class, Y is the image.

The probability density function modified as the following Eq. (4) is,

$$q(Y \mid \varphi_j) = \frac{1}{(2\pi)^{\frac{n}{2}} \left|\sum_j\right|^{\frac{1}{2}}} \exp\left\{-\frac{1}{2}\left(Y - N_j\right)^p \sum_j^{-1} \left(Y - N_j\right)\right\} \tag{4}$$

As shown in Eq. (4) where Σ_j and N_j are the covariance and mean matrices of class φ_j.

Variations between images of the same person and variations between individuals. We define the similarity matching as,

$$E' = q(\Delta \mid \varphi_j) = \frac{1}{(2\pi)^{\frac{n}{2}} \left|\sum_j\right|^{\frac{1}{2}}} \exp\left\{-\frac{1}{2}\left\|j_i - j_l\right\|^2\right\} \tag{5}$$

As shown in Eq. (5) where Δ is the difference vector between two samples j_i and j_l are images stored as interpersonal coefficients as a vector with a whitened sub-space. The idea is to pre-process these images offline so that when facial recognition is performed by an attitude tracking algorithm is much faster.

$$r(q) = F^{-1}\left(g_{jn}\right) - \left(\overline{g} + P_g b\right) \tag{6}$$

As shown in Eq. (6) where $\overline{g}$ is the mean texture in the mean shaped path and P_g is the matrix describing the model variations. g_{jn} is the texture image and parameter b and f is the position of the model points.

B. Input module

In the input device, facial images are obtained from the camera input devices, for example from the Raspberry Pi camera and the Web cameras for face recognition and video frames for individual detection.

C. Processing unit

In the processing unit in which processing or calculations are performed on the proposed individual and lock door device modules, the data collected from the input Image and Video Frames are entered into, where the processing unit is a RASPBERRY-PI panel along with software scripts for the modules implemented.

D. Face recognition module

In this module, we utilized the attitude tracking algorithm for interaction with sensors/actuators through Network Channels, including easy installation/maintenance, flexibility, and low costs, which is used to achieve a global attitude monitoring control Installation/Maintenance. The input camera data means that the face of a person is stored in the database. the output camera. It is transformed into Haar-based cascade classifiers before storing the image using feature extraction.

E. Authentication module

We recognize and detect the input images in this module. This unit is attached to the outside side of the door in which the captured image is converted into Haar classification systems. This extraction image matches the database with this functionality.

F. Application module

Application unit consisting of a door lock circuit is connected to the door locking device authentication module and begins operation based on Face Recognition results according to the module, to open/close the door lock function.

G. OpenCV

OpenCV is an open-source software library that allows developers to access routines used for computer vision applications in the API (Application Program Interface). If someone clicks the doorbell or if the camera senses suspicious activity, the image will be recorded using the software code for activity detection written in Python and OpenCV. After the image is registered, python and OpenCV code are detected and segmented from the frame. The face recognition code for recognizing the faces of the identified faces stored in the database is given as a segmented face.

Proposition 2. *The eigenvalue problem is addressed in the form of the following Eq. (7)*

$$B_y = \Phi \bigwedge \Phi^F \tag{7}$$

$$B_y = \frac{1}{n}\sum_{j=1}^{n} y_j y_j{}^F \tag{8}$$

As shown Eqs. (7) and (8) where B_y is the covariance matrix of the data. $\Phi = [\Phi_1, \ldots \Phi_m]$ is the eigenvector matrix of B_y. $\bigwedge$ is the diagonal matrix.

This process makes the PCA effective without the data covariance matrix having to calculate $B_y = V^F Y$ and the modified Eq. (9) is,

$$Y = VFU^F \tag{9}$$

Proposition 3. *Let us consider the n samples $y_1, \ldots, y_n$ belonging to b classes; every class n_l elements. The objective function of the EATA is defined as the following Eq. (10),*

$$c_{opt} = argmax \frac{c^F E_a c}{c^F E_f c} \tag{10}$$

$$E_a = \sum_{l=1}^{b} n_l \mu^{(l)} \left(\mu^{(l)}\right)^E = \sum_{l=1}^{b} \left(\frac{1}{n_l}\left(\sum_{j=1}^{n_l} y^{(l)}\right)\right)\left(\frac{1}{k_l}\left(\sum_{j=1}^{n_l} y^{(l)}\right)\right)^F = YZ_{nyn}Y^F \tag{11}$$

$$E_f = \sum_{j=1}^{n} y_j y_j^F = YY^F \tag{12}$$

As shown in the above equations where Z_{nyn} is a diagonal matrix defined as (13),

$$Z_{nyn} = \begin{bmatrix} Z^1 & 0 & \cdots & 0 \\ 0 & Z^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & Z^b \end{bmatrix} \tag{13}$$

and Z^l is a $n_l \times n_l$ matrix

$$Z^l = \begin{bmatrix} \frac{1}{n_l} & \frac{1}{n_l} & \cdots & \frac{1}{n_l} \\ \frac{1}{n_l} & \frac{1}{n_l} & \cdots & \frac{1}{n_l} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{n_l} & \frac{1}{n_l} & \cdots & \frac{1}{n_l} \end{bmatrix} \tag{14}$$

Finally, the eigenproblem can be written,

$$E_a c = \lambda E_f c \rightarrow E_f^{-1} E_a c = \lambda Z_{k\times k} Y^F (YY^F)^{-1} c = \lambda c \tag{15}$$

Choosing weights: We can construct Z_{ji} with the heat kernel parameter f as a weight matrix — if nodes j and i are attached,

$$Z_{ji} = e^{-\frac{\|y_j - y_i\|^2}{f}} \tag{16}$$

$$\lambda c = YRY^F (YKY^F)^{-1} \tag{17}$$

As shown in Eq. (17) where R is a diagonal matrix. $K = R - Z$ is a Laplacian matrix.

Face recognition with an attitude tracking algorithm solves the eigenvalue problem for the efficient face recognition with influence factors in the computational model. The proposed EATA algorithm is very efficient and cost-effective for the door lock system as shown in the algorithm 1.

Algorithm:1. Attitude Tracking Algorithm (ATA)

Input: i,j, l

Output: E', Z_{ji}

For i=0

$$E' = q(\Delta \mid \varphi_j) = \frac{1}{(2\pi)^{\frac{n}{2}} \left|\sum_j\right|^{\frac{1}{2}}} \exp\left\{-\frac{1}{2}\left\|j_i - j_l\right\|^2\right\}$$

For j=0

$$E_a = \sum_{l=1}^{b} n_l \mu^{(l)} \left(\mu^{(l)}\right)^E = \sum_{l=1}^{b} \left(\frac{1}{n_l}\left(\sum_{j=1}^{n_l} y^{(l)}\right)\right)\left(\frac{1}{k_l}\left(\sum_{j=1}^{n_l} y^{(l)}\right)\right)^F = YZ_{nyn}Y^F$$

If l=0

$$E_f = \sum_{j=1}^{n} y_j y_j^F = YY^F$$

else

$$Z_{ji} = e^{-\frac{\|y_j - y_i\|^2}{f}}$$

End for

End for

End if

End

Return

In this paper, an Efficient attitude tracking algorithm (EATA) has been utilized for face recognition in the door lock system based on the OpenCV software. The technique is based on which pixels in the image can be analyzed by functions in squares. Machine learning techniques are used to achieve high precision of what is called "training results" and from many positive and negative images is equipped for the feature extraction method in the algorithm. It uses the principle of 'integral image' to measure the detected 'features'. EATA uses a learning algorithm that selects from a wide range a small number of important features to generate an effective classifier result. The EATA algorithm is more accurate and efficient in terms of face recognition.

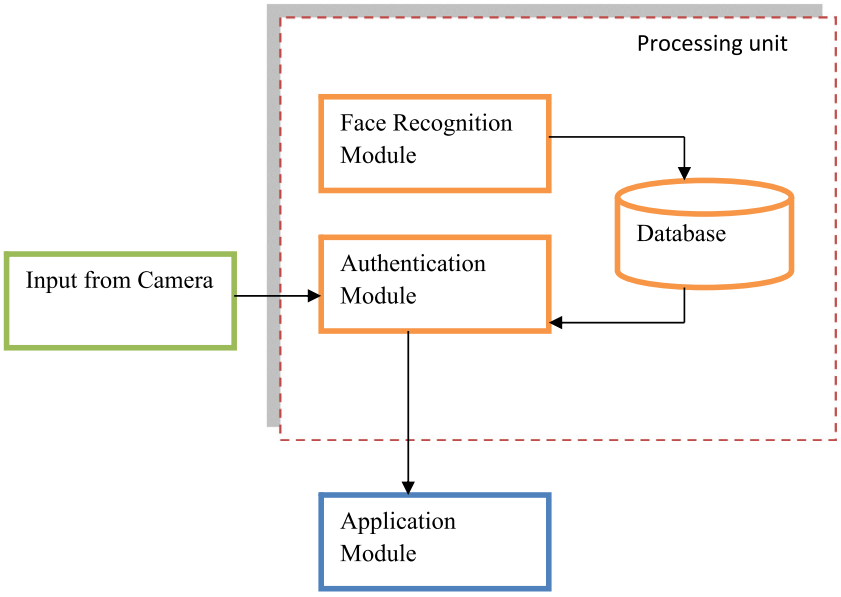

Fig. 3. The proposed system architecture.

Table 1
Efficiency of the proposed EATA method.

Available datasets	ANFIS	FBPCA	JWSC	LBPH	HCCA	EATA
100	58	59	57	64	71	72
200	52	58	60	64	69	67
300	50	60	69	71	72	80
400	63	73	64	73	80	90
500	78	83	85	90	94	98

Table 2
Performance ratio.

Number of datasets	ANFIS	FBPCA	JWSC	LBPH	HCCA	EATA
100	55	59	60	64	71	74
200	52	58	60	64	69	67
300	50	60	69	71	72	80
400	63	73	64	73	80	90
500	80	83	85	90	94	99

3. Experimental results

(i) Efficiency ratio

Face recognition is significant because it is used in many fields of image processing. The research develops an efficient face recognition system based on OpenCV. Face recognition is the best choice for the biometrics issue, and in our individual lives, it has several types of applications. An effective face recognition system can aid in forensic science, law enforcement identifying, banking and security authentication, and giving approved users preferential access such as security access control, etc. The proposed Efficient attitude tracking algorithm (EATA) achieves 96.23% of efficiency when compared to traditional methods such as ANFIS, FBPCA, JWSC, HCCA, LBPH. Fig. 3 and Table 1 show the Efficiency of the proposed EATA approach.

The rule can be changed to take into account various factors that may contribute to mismanagement. Bayesian decision rules can provide an ideal classification, and the Bayes error can be the best criterion for determining features with high efficiency as shown in Table 1.

(ii) Accuracy ratio

The simplest way for the user to achieve optimum accuracy is to take the picture from a close distance, as it must be possible to see the entire face inside this image. The accuracy of the captured image is low because the image captures do not have sufficient information to process. This eliminates this problem with a hierarchical approach. The user image is captured in high resolution and reduced to less than a training image. It also produced a strong recognition level. The proposed Efficient attitude tracking algorithm (EATA) achieves 94.5% of accuracy when compared to traditional methods such as ANFIS, FBPCA, JWSC, HCCA, LBPH. Fig. 4 shows the accuracy of the proposed EATA approach.

(iii) Performance ratio

The system is checked with the same person and multiple datasets including the authorized person and the unauthorized person and the results show that 9 times out of 10 the system detects users. This has a performance of 97% and a tolerance of 10%. But that only occurs when some facial expressions are changed by the user. The proposed Efficient attitude tracking algorithm (EATA) higher performance ratio when compared to traditional methods such as ANFIS, FBPCA, JWSC, HCCA, LBPH. Fig. 5 and Table 2 show the performance ratio of the proposed EATA approach.

Face recognition with an attitude tracking algorithm solves the eigenvalue problem for efficient face recognition with influence factors in the computational model. The best color template to detect faces is very important. Many recent inquiries employ more than one color design. RGB and HSV are used effectively together to increase the performance ratio as shown in Table 2.

(iv) Precision ratio

Face recognition has been the ideal choice for biometrics and in our present lives, there are several applications. The powerful face recognition system can help greatly in forensics, law enforcement identification, Banking, and Security Authentication and preferential access to authorized users, i.e. Secured area controls, etc. The proposed Efficient attitude tracking algorithm (EATA) achieves 95.45% of the precision ratio when compared to traditional methods such as ANFIS, FBPCA, JWSC, HCCA, LBPH. Fig. 6 and Table 3 show the precision ratio of the proposed EATA approach.

As inferred from the Eq. (5) where Δ is the difference vector between two samples j_i and j_l are images stored as interpersonal coefficients as a vector with a whitened sub-space. The idea is to pre-process these images offline so that when facial recognition is performed by an

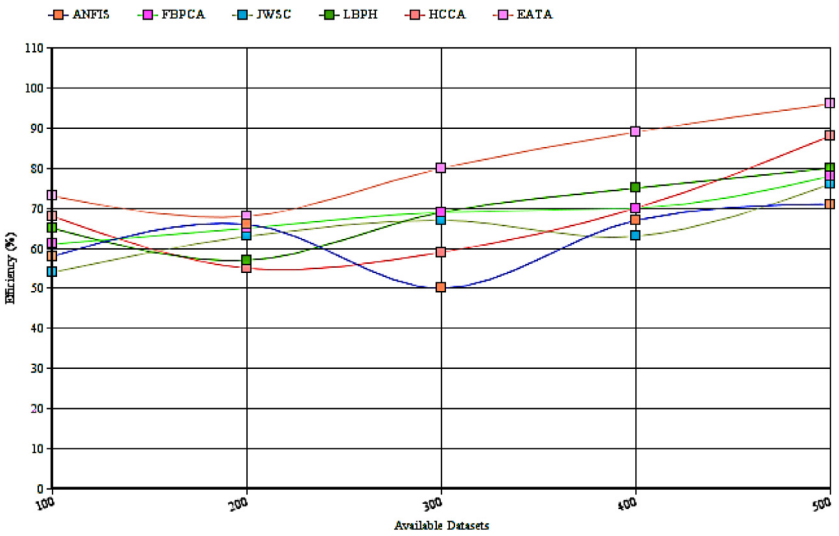

Fig. 4. Efficiency.

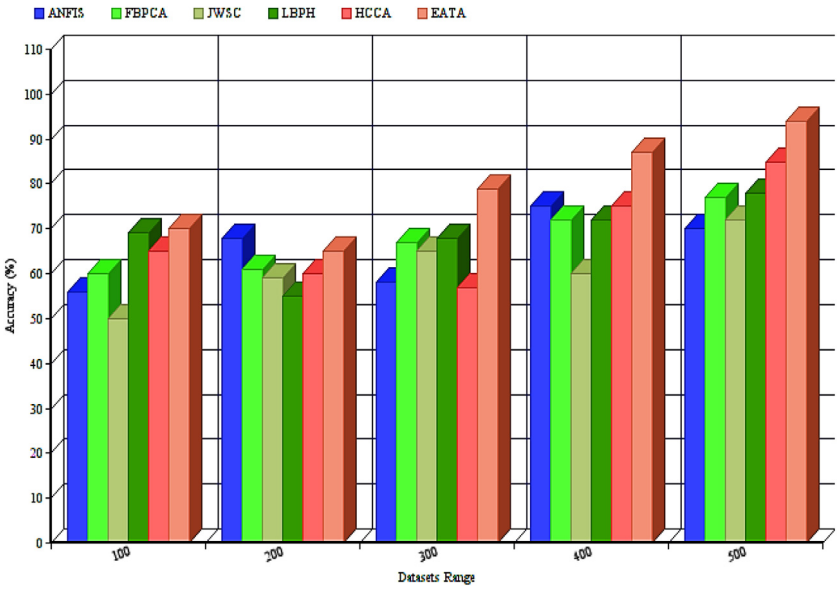

Fig. 5. Accuracy ratio.

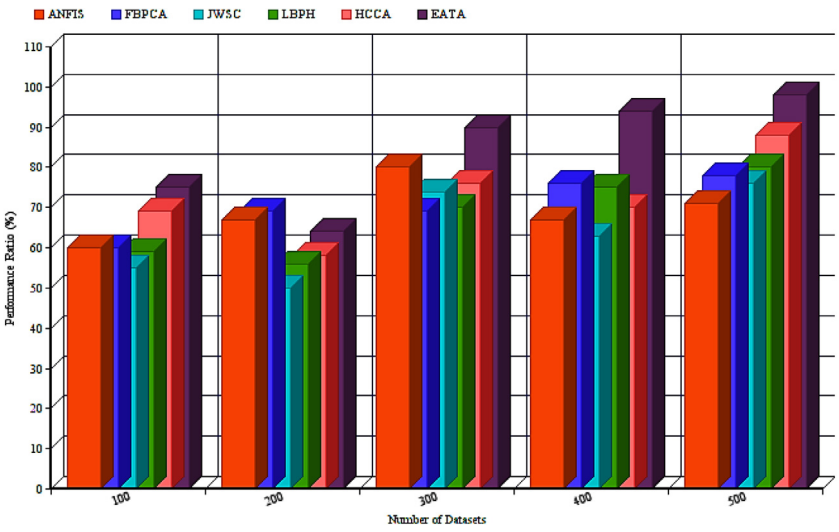

Fig. 6. Performance ratio.

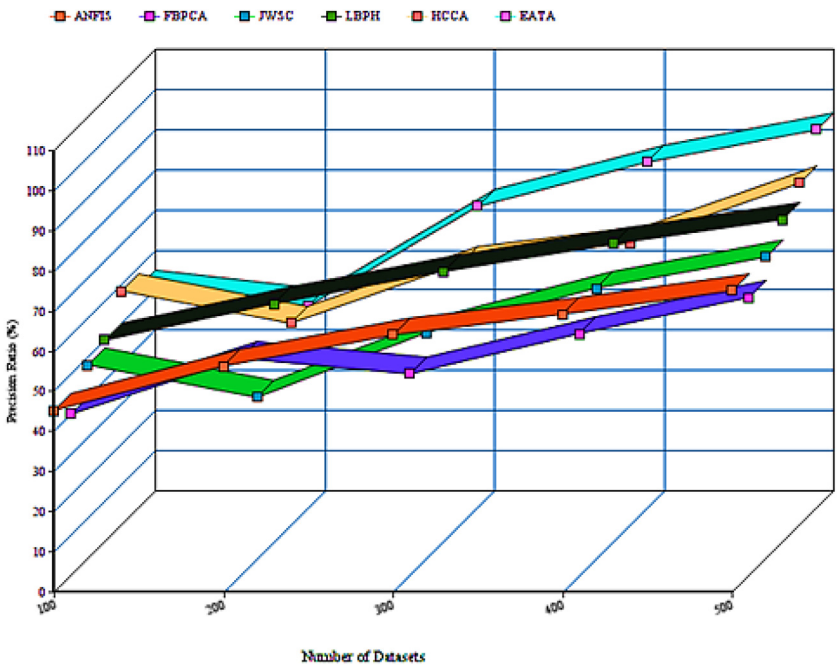

Fig. 7. Precision ratio.

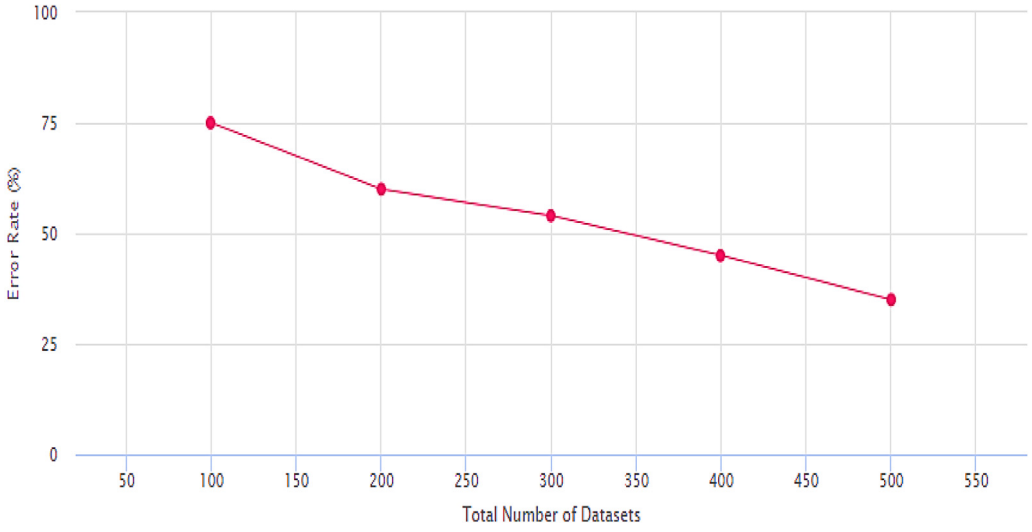

Fig. 8. Error rate.

Table 3
Precision ratio.

Number of datasets	ANFIS	FBPCA	JWSC	LBPH	HCCA	EATA
100	45	46	50	46	59	61
200	49	48	50	64	69	60
300	50	60	69	71	72	80
400	63	80	83	73	80	90
500	80	83	85	86	88	95

attitude tracking algorithm is much faster with the higher precision ratio as shown in Table 3.

(v) Error rate

The arbitrarily minimal error rate for training data can be attained with a good classifier. The good classifier can also be done with the ideal true error rate when the comparison is representative. The proposed Efficient attitude tracking algorithm (EATA) has less error rate when compared to traditional methods such as ANFIS, FBPCA, JWSC, HCCA, LBPH. Fig. 7 shows the error rate of the proposed EATA approach (see Fig. 8).

Furthermore, this article aims to ensure that a key lock system that is retro and modern simultaneously offers a certain safety and reliability. The experimental results show that the proposed system is more efficient, consumes less power, and cost-effective.

4. Conclusion

This paper presents, An Efficient Attitude Tracking Algorithm (EATA) for face recognition based on OpenCV in the Intelligent door lock system. Face recognition is one of the various methods of individual recognition. A dedicated application is developed to enable the operation of devices and the view of the position. For monitoring and security purposes, an automatic door surveillance system with raspberry pi python, USB camera, OpenCV are provided. The system status database has been established at a given time. The device is quite

inexpensive, easy to set up, and easy to operate. The Attitude Tracking Algorithm has very accurate and good performance.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Zhu Zhiguo: Data curation. **Yao Cheng:** Data curation.

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