

Facial Recognition using Locality Preserving Projection Algorithm

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Abstract

Facial Recognition Technology (FRT) has become the research object of many in the recent times considering the challenges with enormous increase in human population. The face as the main axis in social relations plays an important role in the representation of human identity, which requires an increased level of security and the creation of exchange tricks for safe and recognizable evidence and innovations of individual authentication. Apparently, facial recognition is widely adopted for security reasons, and the uniqueness of human characteristics has increased the popularity of facial recognition technology systems worldwide. Law enforcement agencies faced the problem of the impossibility of proper investigation of criminal cases. Suspects are often difficult to catch and the wrong persons may be arrested due to the basis and methods adopted for the investigation. This study proposes a facial recognition system for the identification of criminals using Locality Preserving Projection (LPP) Algorithm. The development of the system involves specification of the functions resulting from the performance analysis obtained from other related systems, and the translation of the developed model into the design of the proposed system. The framework was evaluated by matching the faces of people extracted through special cameras with the images of people on a watch list. Watch lists that contain images of people, including people not suspected of wrong doings. Strategically, the implementation of the facial recognition system was achieved with Locality Preserving Projection (LPP) Algorithm to improve the feature extraction methods and dimensionality reduction techniques. Cascading Style Sheets (CSS) was used for describing the presentation of the document written in HTML language and JavaScript for the front-end for optimum web compatibility. A Python binding of the cross-platform Qt GUI toolkit and Python plugin were used to implement the graphical user interface for detecting and recognizing images and the presence of an individual upon entering the database library. Interestingly, the developed framework recorded accuracy and recognition >95% capacity under normal conditions, including lighting and distance from camera and at a reasonably cheaper cost in comparison with previously proposed Facial Recognition Technology.

Keywords: Facial Recognition Technology, Locality Preserving Projection, Criminal Investigation

1. Introduction

In today's networked world, Facial Recognition Technology (FRT) has emerged as an eye-catching to addressing many modern-day needs for recognition and authentication of uniqueness claims of an individual or group of individuals. The prerequisite for well secured recognizable proof and individual confirmatory innovations is getting to be obvious, hence, face recognition is used widely and primarily for security reasons to trace the uniqueness in traits of humans. Governments, organizations, companies as well as establishments are using facial recognition systems for their entrance controls and security. FRT brings simultaneously the promise of other biometric systems solutions, including fingerprint, palm print, DNA, and iris scans which are greatly used by law enforcement agencies.

In the Armed Forces Command and Staff College, (AFCSC), Jaji, there are procedures for investigations and permission for access through thumbprint. However, with the availability knowledge base to the public, majority of potential criminals are quite aware of thumbprint identification and its impact in tracking culprits, therefore, they often find ways of avoiding thumb marks, sometimes by wearing gloves except for non-premeditated crimes. This study proposed a facial recognition system for the identification of criminals using Locality Preserving Projection (LPP)

Algorithm. The development of the system involves the specification of the functions resulting from the performance analyses obtained from other related systems, and the translation of the developed model into the design of the proposed system.

2. Related Works

Application of Principal Component Analysis (PCA) on Masked and Non-Masked face recognition was proposed in 2016 (Rana et al., 2016). Olivetti and ORL face database were utilized for the implementation and precisely, PCA was used as the feature extraction. The framework was able to record a high face recognition rate without mask. Hammouche et al. (2022) worked on face recognition system which was based on Gobor filter bank and a deep learning method, Sparse Auto Encoder (SAE). The feature was firstly extracted by Gobor filter bank and then the SAE was employed to improve the features extracted by the filter. The features were then subjected to feature reduction using PCA and Linear Discriminant Analysis (LDA) techniques. Furthermore, Cosine Mahalanobis was employed. The evaluation of the study was documented to out-perform previously related studies of similar framework components.

Yu et al. (2022) proposed GoogleNet-M network with the objectives of improving network performance in the basis of streamlining the network, and also to improving the grouping convolution method under multi-GPU applications. The study reported a recall rate of 0.97 and an accuracy of 0.98 which were the yardsticks for proving the algorithm feasible for face recognition. The study of Sun et al. (2022) recorded improvements on the traditional AdaBoost detection method. AdaBoost method was combinatorily used with Kernel Principal Component Analysis (KPCA) and Kernel Fisher Discriminant Analysis (KFDA). The study recorded considerable improvements in comparison to the traditional AdaBoost method and skin colour plus Adaboost method. Moreover, the study also achieved a zero space-based Fisher Discriminant Analysis method which is considered an improvement over the implemented Fisher Discriminant Analysis method. Quantum Neural Network and differentiation of different face patterns was proposed for face recognition by Alrikabi et al. (2022). PCA was used for the extraction of features vectors from images. The reported results showed Quantum Neural Network is efficient significantly for face recognition.

Liyakat et al. (2022) proposed pose invariant human face recognition system using Principal Component Analysis (PCA) as feature extractor with Feed Forward Neural (Multilayer) networks for classification in the recognition of human face irrespective of pose of the faces in the images. The evaluation of the study was rated high, but unfortunately it could only detect straight face's images looking towards camera. Ge et al. (2022) proposed a recognition model using occluded expression and also based on the generated countermeasure network. The researchers designed occluded face image restoration and face recognition representing two distinct modules. The performance evaluation of the facial expression recognition system was found great but it was observed that combining other expression and multimodal models could further improve the system.

Interestingly, the study of Jin et al. (2022) proposed machine learning methodology by obtaining the depth map directly from RGB image thereby improving the performance of subsequent face processing tasks. Generation of depth maps from 2D face images was achieved through data-driven approach. With the study, significant improvement in the accuracy of face recognition was reported. The proposed pseudo RGB-D for face recognition system produced best results with Non-Subsampled Shearlet Transform (NSST).

3. Material and Methods

The system architectural template and the framework for the face recognition were designed and implemented for a functioning web application, consisting of some basic subsystems such as the database and the customized web browser. The system architecture is presented in Fig. 1. while Fig. 2 presents the proposed framework for the study.

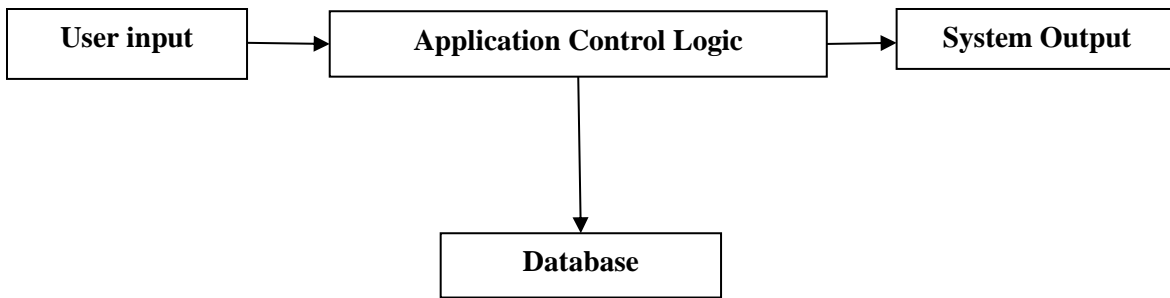


Figure 1: System Architectural Design

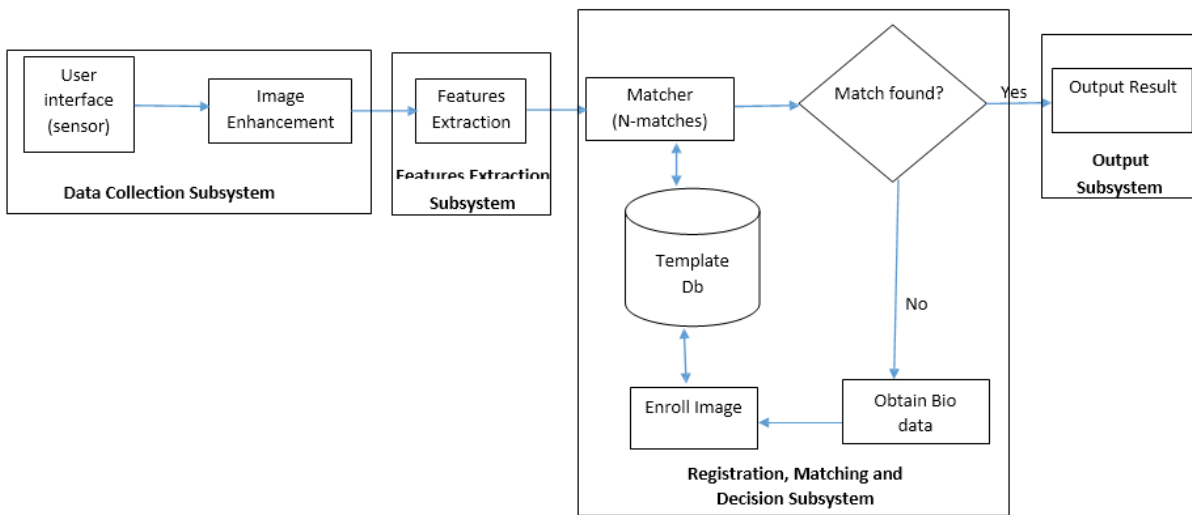


Figure 2: The Proposed Framework

3.1 The System Architectural Design

The architecture for the proposed system is presented in Fig. 1. It deals with the conceptual model that defines the structure components and inter-relationship among the component of the system. The development of the system involves the specification of the function resulting from the performed analysis and the translation of the model into the design of the proposed system. The design specifications that are created at the end of these stages are technical in nature. This involves breaking down the system into subsystems or modules, and each subsystem is further divided into even smaller subsystems. This partitioning process is continuously repeated until each module is small enough to be conveniently implemented as an independent entity that performs a comprehensible operation. The framework for the methodology is presented in Fig. 2.

3.2 Data Collection Subsystem

The data collection subsystem collects images, such as facial images, for registration or matching with already registered images. The subsystem typically uses Closed Circuit Television (CCTV) camera as input device to read or select image for further processing within the application.

3.3 Feature Extraction Subsystem

Data feature is a piece of information specific and unique to a particular image that is relevant to solving a computational problem, and in this case, it can be a characteristic of certain structures in the image, such as points, edges, or objects. Firstly, the pre-processing algorithms developed for feature extraction in SurLens (Adeshina et al., 2012), CAHECA (Adeshina et al., 2014) and ConnectViz (Adeshina & Hashim, 2016) were used for the feature extraction

followed with the integrated Local Preserving Projection (LPP) algorithm, facilitating thorough extraction of the significant features for registration, matching, and decision-making.

Towards the plan to improving the feature extraction methods and dimensionality reduction techniques in the proposed face recognition solution, Local Preserving Projection (LPP) algorithm was utilized. LPP has the ability to preserve the local structure of face image space at a greater significant level far better than what is usually observed with Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). LPP is one of the linear approximations obtained from the non-linear Laplacian Eigenmap (He & Niyogi, 2003). The developed feature extraction algorithm followed the LPP documentation and procedures presented by Shermina (2010).

3.4 Registration, Matching and Decision Subsystem

For future identification, the processed image features were stored in the feature registration subsystem while the input and the processed image features were stored in the image feature input subsystem for required comparison at a later stage in the framework. In the same vein, the input and the processed image features were matched with the registered image features that were stored in the database of the framework. However, the match would only be confirmed if the match meets the required conditions set within the system.

3.5 Output Subsystem

The output subsystem displays a pop-up window with information about the confirmed inmate; output the results of the search for necessary documentation and further processing of the user / administrator.

4. Implementation

The hardware and software of the system were designed and implemented with the ultimate goal of developing a surveillance system which was tested for many live-acquired images and the results were satisfactory for such pioneering work in our laboratory. This includes testing the system to verify its functionality. We also adopted black box testing which is a software testing method that tests the functionality of the system without testing the internal functions and structures, testing the system as a whole for functionality to verify whether it is working properly. In system testing, different images of selected people were taken, their face images obtained in different conditions, and later used to create a training face model containing unique feature vectors for each individual shot taken.

Procedural programming language was chosen for the backend, while HTML, CSS, and JavaScript were chosen in the development of the front-end web pages. A Python binding of the cross-platform Qt GUI toolkit was implemented as a Python plugin. PyQt is a simple yet powerful framework used for the development and graphical user interface. It is used to implement the software interface.

Algorithm 1: Face Detection Algorithm

1. Begin
2. Detect Object in Image
3. Initialize sample for face
4. Convert frame to grayscale
5. Detect frames of different Sizes
 - 5.1. List of faces rectangle
6. Loop for each face
7. Crop the image frame into rectangle
8. Increment sample face image
9. Save captured image into datasets folder Q
10. End

Algorithm 2: Face Recognition Algorithm

1. Begin
2. Import NumPy for matrices calculations

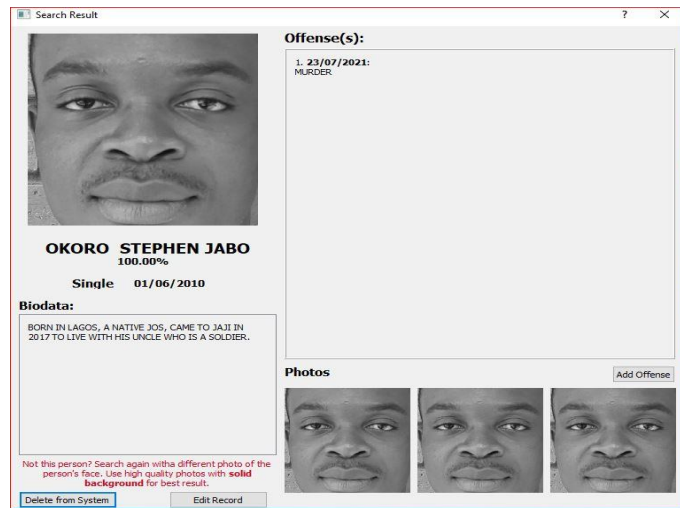
3. Set Return type
 - 3.1 Map True, Id, Confidence, Count
 - 3.1.1 True if face is one
 - 3.1.1.1 Else false
- 4 Create Local Binary Patterns Histograms for face recognition
- 5 Load the trained mode
- 6 Load prebuilt model for Frontal Face
- 7 Create classifier from prebuilt model
- 8 Set the front style
- 9 Read the image file
- 10 Convert the captured frame into grayscale
- 11 Get all face from the picture
 - 11.1 For each face in faces
 - 11.1.1 Identify the face belongs to ID
- 12 Close all windows
- 13 End

Algorithm 3: Locality Preserving Projection (LPP) Algorithm

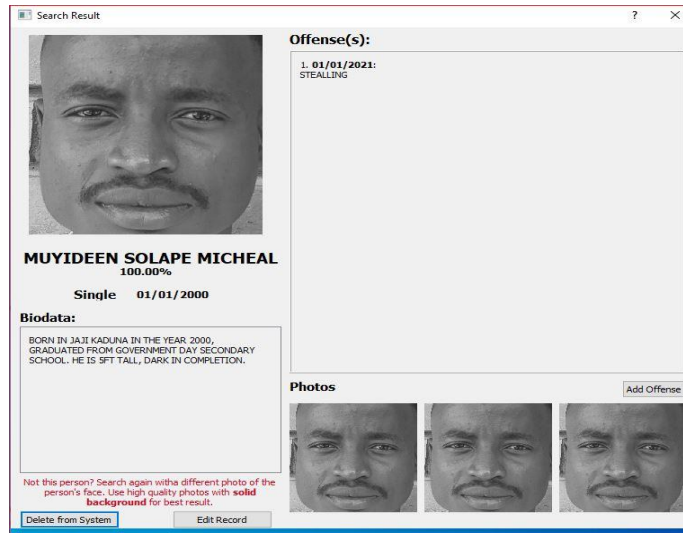
The LPP documentation and procedures presented by Shermina (2010) were adopted and utilized for this study.

5. Results and Discussion

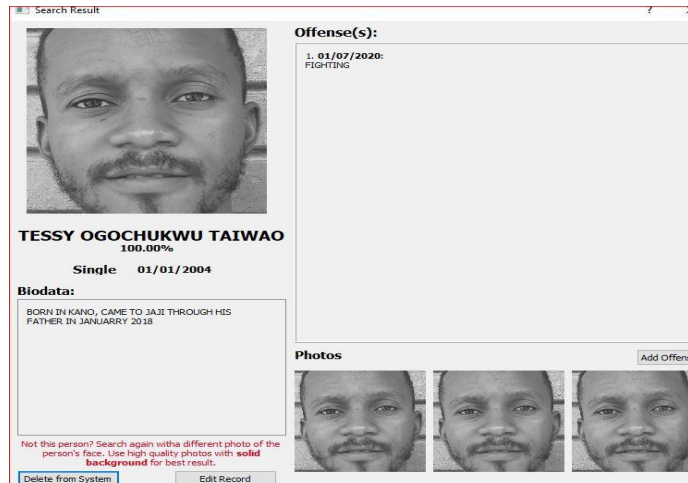
A dataset of at least five images per person was used in the testing and the evaluation. Training and the recognition of faces were achieved in the same environment for efficient face recognition. At every stage of the evaluation, the system is given access to pictures of criminals which would be stored in the system for processing and identification. If the face of the criminal is recognized by the system, a picture of the criminal together with every detail of him/her, which includes the criminal’s name, date of birth, marital status, offenses and etc. would be displayed, attached with a degree of confidence. If the criminal’s face is not recognized by the system the administrator would be notified for further actions.



(a)



(b)



(c)

Figure 3: Criminal Recognition (a-c)

Fig. 3 shows the criminal recognition pattern of the system in identifying a particular criminal. The framework was observed to be very resourceful in capturing the face of criminals, even when the face was not completely in-focus with the camera. However, partial faces for recognition were not considered. The developed framework recorded an accuracy and recognition > 95% capacity under normal conditions, including lighting, and a distance from camera, all at a reasonably cheaper cost in comparison with those previously proposed Facial Recognition Technology

6. Conclusion and Future Work

The proposed face recognition has four main phases, the data collection subsystem, feature extraction subsystem, the registration, matching and decision subsystem, and the output subsystem. The data collection subsystem performs image acquisition, which converts captured images into digital image data. The feature extraction subsystem that facilitates detection composed of white balance correction to acquired image, skin-like region segmentation, facial feature extraction, and face image extraction. White balance correction is an important step to eliminate color changes of acquired image due to illumination condition changes. Skin-like region segmentation performance can be improved by introducing white balance correction before segmentation. Skin color-like region segmentation decreases search time for possible face region since only segmented regions considered as region that may contain faces. In line with related software

development and trend, this project evaluates the limitations attached to manual documentation of criminals and administrative activities as well as the limitations in the existing platforms. Apparently, with this project, we have proposed a better means of handling criminal management system and administrative activities as well as fostering fast retrieval of criminal information.

Further testing and debugging are advised for future work, as this system was developed within a very limited time and resources. Moreover, more attention could be given into researching in other areas using some other algorithms such as neural networks or a more of such in hybrid. Furthermore, the system could be better improved by interfacing the underlying algorithms with high-performance computing resources such as NVIDIA for possible optimum performances.

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