Machine Learning based Face Recognition System

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Abstract –

This paper aims to provide enhanced security by allowing a user to know who is exactly accessing the system using facial recognition. The system allows only authorized users to gain access. Python is a programming language used along with Machine learning techniques and an open source library which is used to design, build and train Machine learning models. Interface mechanism is also provided for unauthorized users to register to gain access with the prior permission from the Admin.

1. INTRODUCTION

This chapter characterizes the introduction of the project Machine Learning Based Facial Recognition System for Virtual Assistant.

Machine Learning is the core part of Artificial Intelligence. Artificial Intelligence is concerned with the design of machines that possess the abilities concerned with humans. In Machine Learning Based Facial Recognition System for Virtual Assistant project, machine learning techniques are used to detect and recognize faces. Here there are two types of users -authorized user and unauthorized user. During the training process the user stands in front of the camera which takes multiple images of him/her. The captured images undergo a face detection process. This process detects faces in the images. The detected faces undergo preprocessing process which is used to reduce the dataset. The preprocessed images undergo feature extraction process which is used to extract facial characteristics. These facial features are then stored in the system. This entire process is carried out under the supervision of the admin.

Face detection, preprocessing and feature extraction are the processes that take place in the testing phase. The extracted facial features are then used for classification. The process of classification classifies data into predefined classes. After classification the face is identified as a authorized user or unauthorized user. If it is an authorized user, he/she is given access to the system. The user can then avail the services of the virtual assistant. The virtual assistant provides services like fetching information from Wikipedia. In case of an unauthorized user, he/she is prompted to register with the admin. The register process includes capturing images of the user under the supervision of the admin.

There exists considerable current interest to develop an automated system for rapid and authenticidentification of a person's identity. Machine recognition of human face offers a non-intrusiveand perhaps the most natural way of person identification. In contrast to the much establishedauthentication criteria such as passwords, PINs (Personal Identification Numbers) or magneticcards, this biometric approach provides a convenient and more secured means of personidentification being unique to an individual. Although several other biometric authenticationmethods based on other physiological characteristics (such as fingerprint, retina and iris patterns,hand geometry, and voice) are also being investigated, such biometric identification systemsmostly rely on the cooperation of the participants. Authentication using face recognition offersthe advantage of being intuitive and often effective without the participants' cooperation orknowledge. Moreover, it is also convenient to use in the sense that it does not need to be carried Individually by the user.

Application areas of face recognition are broad. These include identification for law enforcement,matching of photographs on passports or driver's licenses, access control to secure computernetworks and other sensitive facilities, authentication for secure banking and financialtransactions, automatic screening at airports for known terrorists, and video surveillance usage.Such applications range from static matching of controlled format photographs to real-timefetching of video image sequences. In the computer security area, a face recognition system canbe used to continually re-verify the identity of the system's user, and to confirm authorizationlevel prior to performing each action.

The technique of face recognition addresses the problem of identifying or verifying one or morepersons of interest in a scene by comparing input faces with the face images stored in a database.While humans quickly and easily recognize faces under variable situations or even after severalyears of separation, the human brain has its shortcomings in the total number of persons it canaccurately "remember". The benefit of a computer system would be its capacity to handle largedata sets of face images. While the task is relatively easier in a controlled environment wherefrontal and profile photographs of human faces are present (with a uniform background andidentical poses among the participants), it is a highly challenging task in an uncontrolled or less controlledenvironment where a scene may or may not even contain a set of faces. The situationcan be even worse because of the possibility of a face image getting cluttered due to the influenceof a lot of circumstantial variables. Moreover, human faces look similar in structure with minordifferences from person to person. Classical pattern recognition problems such as characterrecognition have a limited number of classes, typically less than 50, with a large number oftraining samples available for each category. In face recognition, on the other hand, relativelysmall number of face images is available for training while there exist a large number of possibleface classes. A successful machine recognition system therefore requires a robust and efficientalgorithm that can best detect a human face from the still or video image of a scene and

accurately recognize it (i.e. correlate it to the right individual) using a stored database of faceimages. Development of such algorithms comprises of three major aspects: face detection, featureextraction, and recognition. The goal of face detection is to segment out face-like objects fromcluttered scenes. Feature extraction finds relevant information with good discriminatingcapability from the detected face region. Face images are usually represented in terms of featurevectors in lower dimensional feature space for recognition. Recognition tasks cover both faceidentification and face verification. Face identification refers to the process that given unknownface input, the system reports its identity by looking up a database of known individuals. Inverification tasks, the system confirms or rejects the claimed identity of the input face. Additionalinformation such as race, age, gender, and facial expression can be used to enhance recognitionaccuracy.

FACE DETECTION AND FEATURE EXTRACTION

2.1 Face Detection

Detecting and tracking of face-like objects in cluttered scenes is an important preprocessing stageof an overall automatic face recognition system [2-3]. Face region needs to be segmented outfrom a still image or a video before recognition since most face recognition algorithms assumethat the face location is known. The performance of a face recognition algorithm depends on howone controls the area where faces are captured. For applications like mug shot matching,segmentation is relatively easy due to a rather uniform background. For a video sequenceacquired from a surveillance camera, segmentation of a person in motion can be accomplishedusing motion as a cue. Color information also provides a useful key for face detection whilecolor-based approaches may have difficulties in detecting faces in complex backgrounds andunder different lighting conditions.

Face detection can be viewed as special case of face recognition, a two-class (face versus non-face)classification problem. Some face recognition techniques may be directly applicable todetect faces, but they are computationally very demanding and cannot handle large variations inface images. Conventional approaches for face detection include knowledge-based methods,feature invariant approaches, template matching, and appearance-based methods. Knowledgebasedmethods encode human knowledge to capture the relationships between facial features.Feature invariant approaches find structural features that exist even when the pose, viewpoint, orlighting conditions vary. Both knowledge-based and feature invariant methods are used mainlyfor face localization. In template matching methods, several standard patterns of a face are storedto describe the face as a whole or the facial features separately. The correlations between an inputimage and the stored patterns are computed for detection. The templates are also allowed totranslate, scale, and rotate. Appearance-based methods learn the models (or templates) from a setof training images to capture the representative variability of facial appearances. This category ofmethods includes various machine learning algorithms (e.g. neural networks, support vectormachines etc.) that detect upright and frontal views of faces in gray-scale images.The analytic approaches, which concentrate on studying the spatial domain feature extraction, seem tohave more practical value than the holistic methods. In these approaches specific facial

features areextracted manually or automatically by an image processing system and stored in a database. A searchmethod is then used to retrieve candidates from the database.

Feature Extraction for Face Recognition

Face recognition involves feature matching through a database using similarity or distancemeasures. The procedure compares an input image against a database and reports a match.Existing face recognition approaches can be classified into two broad categories: analytic andholistic methods. The analytic or feature-based approaches, which concentrate on studying thespatial domain feature extraction, compute a set of geometrical features from the face such as theeyes, the nose, and the mouth. The use of this approach has been popular in the earlier literature.

The holistic or appearance-based methods consider the global properties of the human facepattern. The face is recognized as a whole without using only certain fiducial points obtainedfrom different regions of the face. Holistic methods generally operate directly on pixel intensityarray representation of faces without the detection of facial features. Since detection of geometricfacial features is not required, this class of methods is usually more practical and easier toimplement as compared to geometric feature-based methods.

A combination of analytic and holistic methods has also been attempted. For example, Lam et al[6] combined 16-point features with regions of the eye, the nose, and the mouth and demonstratedsuccess in the identification of the faces at different perspective variations using the databasecontaining 40 frontal-view faces. The method was composed of two steps. The first stepemployed an analytic method to locate 15 feature points on a face: face boundary (6), eye corners(4), mouth corners (2), eyebrows (2), and the nose (1). The rotation of the face was estimatedusing geometrical measurements and a head model. The positions of the feature points wereadjusted so that their corresponding positions in the frontal view get approximated. These featurepoints were then compared with those of the faces in a database. Only the similar faces in thedatabase were considered in the next step. In the second step, feature windows for the eyes, nose,and mouth were compared with the database by correlation. The two parts were combined to forma complete face recognition system. This approach achieved a high recognition rate underdifferent perspective variations.

3. FACE RECOGNITION ALGORITHMS

A number of earlier face recognition algorithms are based on feature-based methods that detect aset of geometrical features on the face such as eyes, eyebrows, nose, and mouth. Properties andrelations such as areas, distances, and angles between the feature points are used as descriptorsfor face recognition. Typically, 35-45 feature points per face are generated. The performance offace recognition based on geometrical features depends on the accuracy of the feature locationalgorithm. However, there are no universal answers to the problem of how many points give thebest performance, what the important features are, and how to extract them automatically. Facerecognition based on geometrical feature matching is possible for face images at low resolution as8×6 pixels when the single facial features are hardly revealed. This implies that the overallgeometrical configuration of the face features is sufficient for recognition.

Appearance-based face recognition algorithms proceed by projecting an image into the subspaceand finding the closest point. Two well-known linear transformation methods that have been most widely used for dimensionality reduction and feature extraction are the Principal ComponentAnalysis (PCA) and Linear Discriminant Analysis (LDA). While the objective of PCA is tofind a transformation that can represent high dimensional data in fewer dimensions such thatmaximum information about the data is present in the transformed space, the goal of LDA is toperform dimension reduction while preserving as much of the class discriminatory information aspossible. Several leading commercial face recognition products use face representation methodsbased on the PCA or Karhunen-Loeve (KL) expansion techniques, such as eigenface and localfeature analysis (LFA). Multispace KL is introduced as a new approach to unsupervisedimensionality reduction for pattern representation and face recognition, which outperform KLwhen the data distribution is far from a multidimensional Gaussian. In traditional LDA,reparability criteria are not directly related to the classification accuracy in the output space.Object classes that are closer together in the output space are often weighted in the input space toreduce potential misclassification. The LDA could be operated either on the raw face image toextract the Fisherface or on the eigenface to obtain the discriminateeigen features.

Featurerepresentation methods that combine the strengths of different realizations of LDA methods havealso been recently proposed. Kernel PCA and generalized discriminant analysis (GDA)using a kernel approach have been successful in pattern regression and classification tasks.

Motivated by the fact that much of the important information may be contained in the high-orderrelationships, face recognition based on the independent component analysis (ICA) is proposedrecently as a generalization that is sensitive to higher-order statistics, not second-orderrelationships. ICA provides a set of basis vectors that possess maximum statistical independencewhereas PCA uses eigenvectors to determine basis vectors that capture maximum image variance.

Face recognition techniques based on elastic graph matching, neural networks andsupport vector machines (SVMs) showed successful results. Line edge map approach extracts lines from a face edge map as features, based on a combination of template matching andgeometrical feature matching. The nearest feature line classifier attempts to extend thecapacity covering variations of pose, illumination, and expression for a face class by finding thecandidate person owning the minimum distance between the feature point of query face and thefeature lines connecting any two prototype feature points. A modified Hausdorff distancemeasure was also used to compare face images for recognition.

In the following, we shall briefly discuss the basic ideas of a face recognition algorithm takingeigenface recognition, the most widely reported approach, as an example.Given a set of face images labeled with the person's identity (the learning set) and an unlabeledset of face images from the same group of people (the test set), the basic task of a face recognitionalgorithm is to identify each person in the test images. Perhaps, the simplest recognition schemeis to use a nearest neighbor classifier in the image space. Under this scheme, an image in the testset is recognized (classified) by assigning to it the label of the closest point in the learning set,where distances are measured in the image space. If all of the images are normalized to have zeromean and unit variance, then this procedure is equivalent to choosing the image in the learning setthat best correlates with the test image. Because of the normalization process, the result isindependent of light source intensity and the effects of a video camera's automatic gain control.

This procedure, which subsequently is referred to as correlation, has the major disadvantage inthat it is computationally expensive and requires large amounts of storage. This is because wemust correlate the image of the test face with each image in the learning set and the learning setmust contain numerous images of each person. So, in order for this method to work efficiently, itis natural to pursue dimensionality reduction schemes. A technique most commonly used fordimensionality reduction in computer vision is principal components analysis (PCA) and thecorresponding algorithm in the context of face recognition is called eigenfacemethod. In fact, theeigenface method generates features that capture the holistic nature of the faces through

Architecture Diagram shows the relationship between different components of a system. The figure shows the architectural diagram of the proposed system.

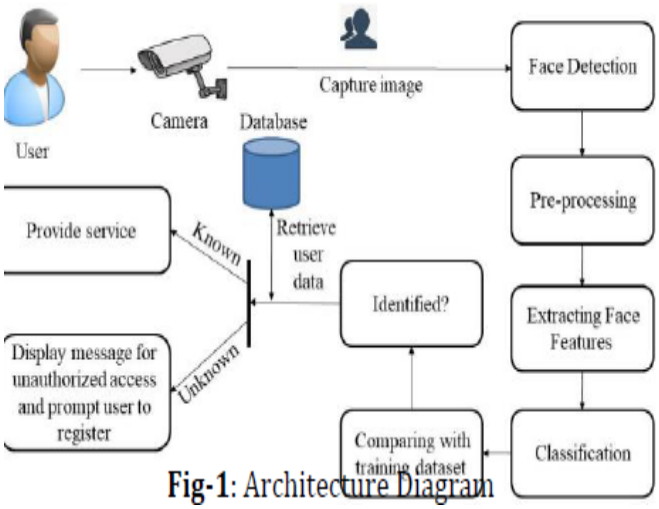

Fig-1: Architecture Diagram

The proposed system consists of a camera that captures images of a user. These captured images are then sent to the Face Recognition System(FRS) which further does pre-processing, face detection and feature extraction. Classification step is used to identify whether the user is authorized or not. If it is an authorized user, service is provided to it in the form of virtual assistant. Otherwise, the user is prompted to register with the admin.

A dataflow diagram gives a graphical representation of a flow of data through the system. It is used to provide an overview of the system. In the proposed system user and camera acts as external entities. During the training process the camera is used to capture the images. The captured images are send to face detection

process which gives the detected faces as the output. These are further sent to the preprocessing process which reduces the data set. The preprocessed images are sent to the feature extraction process which gives facial features as the output which is then saved in the system. During the testing phase face detection, preprocessing, feature extraction is carried out along with classification process, the classification process is used to detect the user's status. If it a valid user, he/she is provided with service in the form of virtual assistant. If it is an invalid user, he/she is prompted to register with the admin.

Humans often use faces to recognize individuals and advancements in computing capability over the past few decades now enable similar recognitions automatically. Early face recognition algorithms used simple geometric models, but the recognition process has now matured into a science of sophisticated mathematical representations and matching processes. Major advancements and initiatives in the past ten to fifteen years have propelled face recognition technology into the spotlight. Face recognition can be used for both verification and identification (open-set and closed-set). In face recognition system it identifies faces present in the images and videos automatically. It is classified into two modes: 1. Face verification (or authentication) 2. Face identification (or recognition) In face verification or authentication there is a one-to-one matching that compares a query face image against a template face image whose identity is being claimed. In face identification or recognition there is a one-to-many matching that compare a query face image against all the template face images in the database to determine the identity of the query face image. Another face recognition scenario involves a watch-list check, where a query face is matched to a list of suspects (one-to-few matches). The performance of face recognition systems has improved significantly since the first automatic face recognition system was developed by Kanade (T.Kanade, 1973). Furthermore, face detection, facial Feature extraction, and recognition can now be performed in real-time for images captured under favorable (i.e. constrained) situations. Although progress in face recognition has been encouraging, but still there are some unconstrained tasks where viewpoint, illumination, expression, occlusion, accessories, and so on vary considerably. It is natural, nonintrusive, and easy to use. There are many biometric systems but

among the six famous biometric attributes considered by Hietmeyer(R.Hietmeyer, 2000), In a Machine Readable Travel Documents (MRTD) system facial features scored the highest compatibility, such as enrollment, security system, machine requirements, renewal, surveillance system and public perception, shown in Figure1. Figure 1: A comparison of various biometric features based on MRTD compatibility (R Hietmeyer,2000). Face Recognition Processing Face recognition is a visual pattern recognition problem. There, a face as a three-dimensional object subject to varying illumination, pose, expression and so on is to be identified based on its two-dimensional image (three-dimensional images e.g., obtained from laser may also be used). A face recognition system generally consists of four modules as depicted in Figure 2: detection, alignment, feature extraction, and matching, where localization and normalization (face detection and alignment) are processing steps before face recognition (facial feature extraction and matching) is performed. Face detection segments the face areas from the background. In the case of video, the detected faces may need to be tracked using a face tracking component. Face alignment is aimed at achieving more accurate localization.

RESULTS

The basic idea of PCA is to find an optimal linear transformation that maps the original dimensionaldata space into an m-dimensional feature space (m <n) to achieve dimensionalityreduction. The PCA algorithm chooses a dimensionality reducing linear projection thatmaximizes the scatter of all projected samples.

In practice, for a given input matrix **X**, finding the eigenvectors of the scatter matrix **XXT**, of sizen×nis an intractable task for typical image sizes. For images of size 128×128, for example, thedimension is n = 1282 and the size of the scatter matrix **XXT** becomes 1282×1282 @ 2.7×108.

Hence, a simplified method of calculation is adopted. Since the number of training images isusually much smaller than the number of pixels in an image (N <<n), the eigenvectors F andassociated eigenvalues l of **XXT** can be found from the eigenvectors F/ and associatedeigenvalues l/ of **XTX**, which are mathematically better tractable and easier to obtain. Theeigenvectors are F=**X**F/ and the eigenvalues remain the same (l=l/).Figure 1(a) shows a trainingset used to compute the eigenfaces in Figure 1(b). A set

of eigenfaces has been computed for 25normalized face images of 100×100 size.

(a)

Figure 1: Computation of the eigenfaces from a set of face images. (a) Sample training set; (b)eigenfaces

CONCLUSION

The proposed system ensures that only an authorized user can access the system and avail the services of Virtual Assistant. The benefits include tighter security, ease of access and usage even by a physically handicapped person.

Machine recognition of human face is an active research field due to wide variety of commercialand law enforcement applications including access control, security monitoring, and videosurveillance. This report discusses the various aspects of automated face recognition techniquesand provides a brief overview of major efforts and advances in the field. Although visual facerecognition systems have demonstrated high performance under consistent lighting conditions,such as frontal mug shot images, thermal IR face recognition techniques are useful for identifyingfaces under uncontrolled illumination conditions or for detecting disguises. Face recognitionperformance can be further enhanced by the fusion of visual information obtained fromreflectance intensity images and anatomical information obtained from thermal IR images therebymaking available information that cannot be obtained by processing visual images alone orthermal images alone.

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