

A Review of Various Face Recognition Methods

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Abstract: Face recognition, the fastest growing biometric technology of computer vision, made a breakthrough in the field of security, healthcare, access control and marketing etc. This technology helps in identifying the faces for authentication by comparing available digital image of faces. Various algorithms have been developed for enhancing the performance of face recognition system. The face authentication system entails three major steps, face detection, feature extraction and face recognition. This paper elucidates various techniques of face recognition like holistic learning approach, hybrid approach and deep learning approach. Periocular region is the feature rich region around the eye which may include features like eyelids, eyelashes, eyebrows, tear duct, eye shape, skin texture and more. This paper provides a comprehensive survey of periocular biometrics and a deep insight of various aspects such as utility of periocular biometrics and a deep insights of various aspects such as utility of periocular region as different modality like stand – alone modality and periocular region and its fusion with iris.

Keywords: Face Recognition, Holistic Learning, Feature Extraction, Deep Learning, Convolution Neural Network, Periocular Region

1. Introduction

Face recognition, the quickest developing biometric innovation of PC vision, made an achievement in the field of security, medical services, access control and promoting and so on this innovation helps in consequently observe and distinguish the faces. Periocular-based biometrics alludes to the automatic recognition or arrangement of an individual dependent on highlights separated from the space of the face which encompasses the eye. Commonly, the facial region used reaches out from the highest point of the eyebrow to the cheekbone and incorporates the region from the midline of the nose to right inside the ear. Potential highlights found in the periocular area which can be utilized for biometric applications incorporate the upper/lower eyelids, the upper/lower eye folds, different skin sores (moles, spots), eye corners, eyebrows, just as skin tone/surface. One of the inspirations for periocular-based biometrics is that highlights from the periocular area can be utilized in circumstances in which the face is somewhat blocked (nose, mouth covered) forestalling facial acknowledgment. The face verification framework involves three significant advances, face location, highlight extraction and face acknowledgment. In this paper the significant approaches of face portrayal for acknowledgment like all learning approach, highlight based methodology, half breed approach and profound learning approach. In the part of literature different methods of classifications are used. Finally, convolutional neural network is used for the facial acknowledgement. The face confirmation, planning of the given face is done balanced against the known character. In the subsequent mode, face ID is finished by planning of one face to numerous countenances accessible in the dataset. Different technique and calculations are created which has improved the capacity of precisely perceiving the face. The FR framework comprises of the accompanying significant advances:

- 1) Formation of dataset of Image.
- 2) Face location
- 3) Extraction of highlights
- 4) Acknowledgment

Creation of dataset: The dataset is set up by catching the picture through webcam, pictures or pre-prepared informational collections accessible in net.

Face recognition: The pictures in the informational collection is looked at, faces are found consequently from the given picture or video and bounding box is made around the face.

Extraction of Features: After discovery of face, include extraction is performed by measurement decrease, data pressing and commotion cleaning and so forth. On the off chance that face patches are not separated, at that point acknowledgment framework will be excessively huge and hearty to assemble.

Acknowledgment: The countenances are named by giving name for the recognized face. Facial highlights are planned from the picture or video and which is contrasted and the accessible pictures in the information base. At the point when the coordinating is affirmed, the face will be distinguished.

The various strategies for face acknowledgment approaches are all - encompassing learning approach, include based methodology, half and half methodology and profound learning approach. Face acknowledgment has wide application zone like access control, law authorization, security, distinguishing proof of criminal, opening of telephone, discovering lost individual, guide for aiding the visually impaired, measurable examination help, people ID through online media stages, conclusions of sicknesses, schools and school participation confirmation framework, secure instalment exchange, ticket age in air terminals and numerous others. In the second part of this paper, writing audit has been done on various methodologies of face acknowledgment.

2. Literature Review on Different Approaches of Face Recognition

A. Holistic Approach:

In this methodology, the whole face territory is considered as a solitary element which is additionally coordinated with accessible face picture in dataset. The Holistic methodology can be either factual methodology or Artificial Intelligence approach. In the main methodology the thickness of the face picture is determined and the got set estimation of thickness is contrasted and the estimations of the dataset pictures. In

the subsequent methodology instruments like neural organization is utilized [1]. A portion of the comprehensive learning approach are Eigen face technique, Principle segment examination (PCA) method, Fisher face approach, Local double pattern (LBP) approach, Independent part investigation, Linear discriminator examination.

Face acknowledgment, acted in [2] by Eigen face, fisher face just as neighborhood parallel example with examination of achievement rate. In the proposed framework Viola John face discovery technique is utilized. Portrayed better execution and speed with LBP approach. The sifting framework utilized for every one of the three strategies, in view of Euclidean distance computation. Changing aftereffect of achievement rate has been proposed because of posture, light and appearance on account of Eigen face and fisher face technique. Another model showed in [4] utilizes Eigen face strategy with various condition and 79% and 65% precision got. Relative examination made on ICA affectability to space measurement and discriminant execution of ICA is proposed in [3]. A framework with fisher face approach, wherein the face space is decreased by PCA and fisher's direct discriminator has been utilized for include extraction. The acknowledgment of face is performed by Euclidean space. The preparing is done Matlab programming language. Adobe Photoshop Cs4 program is utilized for preprocessing of picture. The outcomes claims, 93% of precision on 73 test picture with the sign of the reasons of disappointment as scaling variable and posture [5]. Face acknowledgment by straight paired example strategy Illustrated in [6] depicted a framework in which face picture has been partitioned into 7x7 equivalent size cell. A decimal worth has been appointed to the pixels. The limit esteem is chosen dependent on the loads of the adjoining cell. At the point when the coordinating of face is discovered same according to the dataset, the entryway of the homeroom will open as the entryway is associated with the servo engine and the participation is entered in the MySQL information base. 95% precision got on 11 man's picture. A FR framework gave in [7], utilizes Viola and John's calculation for face recognition, which is trailed by FR by both Eigen face and PCA strategy to conquer the issues, identified with light and posture.

B. Highlight Based Approach

In this methodology the highlights like, mouth, nose, jaw are separated and taken care of to the classifier. A portion of the element based methodologies are Elastic Bunch Graph Matching (EBGM), format coordinating strategy. In format coordinating, designs are addressed by predefined test, model, surface, pixel and so forth relationship or distance is utilized as acknowledgment capacity to find the given personality. In layout technique the face is separated into eye, mouth and face form and generally utilized identification strategy is edge location. FR dependent on mathematical highlights with Euclidean distance proposed by Kanade [8] includes calculation of mathematical highlights, for example, nose width and length of the mouth position, state of jawline and so on from the given face. He has coordinated the highlights with the highlights of known person. Nearest coordinate was accomplished by Euclidean distance. The test was performed utilizing 800 photos. Tests were conveyed with 20 people.

In the EBGM approach, the countenances are embodied as charts with hubs arranged at fiducial focuses. Naming has been done at edges with 2D distance vectors. Fly Gabor coefficients from each focuses were separated physically by finding fiducial focuses like eyes, nose and so forth on the picture. Dynamic connection engineering is made by Gabor wavelet change which shows the face in flexible network. The consequence of Gabor channel is accommodated the element extraction and shape discovery [9].

C. Crossover Approach

Both the all-encompassing learning approach and highlight extraction approach together is utilized in mixture approach. In an illustration of cross breed technique, portrays two modes. The primary mode is the preparation mode and the subsequent mode is characterization. In the preparation of picture, preparing set, highlight extraction by head segment investigation (PCA) and autonomous part examination (ICA) is proposed. Back spread neural organization (BPNN) is utilized for preparing and is done in corresponding to acquire diverse face classes by parceling the component space. Arrangement is additionally proposed by PCA-BPNN or ICA-BPNN dependent on the face class. Testing is performed on ORL data set. The outcome proposed reflects PCA usage more vulnerable than ICA [10]. Another model proposed in [11] proposes PCA and Artificial Neural Network. Acknowledgment is performed dependent on the light, feelings and commotions. The acknowledgment rate noticed for ideal case was 93.5% and for commotion influenced picture, the acknowledgment rate noticed was 85%. Acceptable execution has been proposed utilizing feed forward calculation. Also, crossover approach has been utilized for discovery and acknowledgment by PCA and K-mean bunching in [12]. Another promising illustration of half and half model, which joins the properties of highlight and comprehensive based technique alongside Markov irregular field (MRF). In this work picture of the face is partitioned into portions, and the model shows a connection between sections or fix ID and face patches. ORL data set, Yale information base and FERET data set for four strategies, Markov irregular field (MRF), PCA, straight Discriminator Analysis (LDA) and Neural Network (NN). The proposed model shows proof of having preferred execution over PCA and LDA strategies [13].

D. Profound Learning Approach

Deep learning approach immensely affects research dependent on FR. It offers better execution as for speed and exactness. Most basic technique for profound learning strategy is convolution neural network (CNN) [14], a feed forward neural organization comprised with numerous layers, for example, convolution layer, pooling, amended straight unit (ReLU layer) and completely associated layers. Convolution layer has free channels and channels are convolved with the picture, are answerable for extraction of highlights. The CNN layer is trailed by pooling layers, answerable for lessening the measurement, which thus diminishes number of boundary and calculation in the organization. The way toward pooling abbreviates the preparation time and powers over fitting. One of the regularly utilized pooling techniques is max pooling. Next layer is amended direct unit, an initiation work with not evaporating slope, computationally productive, gives better

intermingling execution utilized in practically all profound learning approach. The yield of convolution and pooling is gotten by completely associated layer to foresee the best mark to portray the face picture.

Juefei-Xu et al. (2019) investigated distinctive type of Discrete Transform encoded LBP (DT-LBP) includes and noticed an intriguing truth that if just 40% of the full face is obvious, DT-LBP based periocular framework is performing better compared to confront biometric confirmation framework. Bhardwaj et al. (2010) contemplated the impact of camera deadlock distance on the exhibition of periocular biometrics and found that 6 m to 7 m is an ideal distance for catching the pictures of periocular locale.

Gangwar and Joshi (2018) utilized the mix of Local Phase quantization (LPQ) and Gabor size descriptor for include extraction to show the adequacy of stage descriptors (invariant to obscure and uniform enlightenment) in periocular biometrics.

Bakshi et al. (2018) too asserted the handiness of stage data and proposed a worldwide component descriptor named as Phase Intensive Global Pattern (PIGP). PIGP relies upon variety of power of neighborhood pixels w.r.t various stages. As an expansion of their work (Bakshi et al., 2015) concocted a plan to make a neighborhood descriptor utilizing stage data of central issues of pictures as opposed to utilizing worldwide descriptor known as Phase Intensive Local Pattern (PILP).

To lessen the dimensionality of highlight vectors without influencing the acknowledgment exactness of periocular based framework, Adams et al. (2010) and Dozier et al. (2011) concocted a component streamlining procedure dependent on Genetic and Evolutionary registering and called as Genetic and Evolutionary Feature Extraction technique (GEFE). They applied GEFE on LBP highlight vector for improvement and saw that streamlined list of capabilities accomplished higher acknowledgment rate as contrast with unique LBP include vector on FRGC (Phillips et al., 2005) and FERET (Phillips et al., 1997) information base.

Uzair et al. (2013, 2015) detailed periocular biometrics as picture set (right eye of an individual was reflected and joined with left eyes) grouping issue. They executed four element extraction and six cutting edge picture set order procedures. By applying two sorts of combination one at highlight and other at classifier level they noticed the compromise that picture set based strategy accomplished higher acknowledgment rate yet extravagant regarding calculation time. To address this issue, they utilized PCA and LDA highlight streamlining calculation to advance the highlights which lessen the calculation time. Rundown of approaches for periocular as independent methodology. Smereka et al. (2019) applied an unaided fix choice methodology on pictures to discover the best segregating locale. For this, first gap the picture in to lattices and discover introductory fix similitude (utilizing connection channel) at that point banner the area with helpless match

score and join those patches with their area to acquire new fixes to improve execution of 1:1 picture coordinating precision.

Zhao et al. (2019) built up a semantic helped convolutional neural organization. The idea was to add some extra CNN branch (prepared with the semantic data like sex and identity) to previously existing CNN.

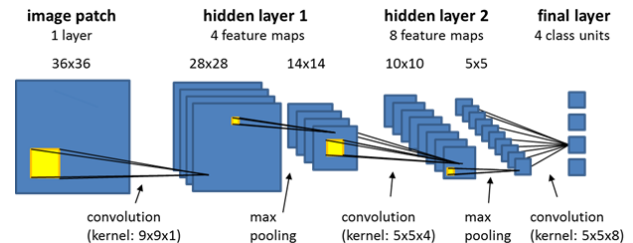


Figure 1: Convolution Neural Network

A portion of the models used to actualizing profound learning based face acknowledgment are: DeepFace, DeepID, FaceNet, AlexNet based CNN strategy, Improved AlexNet CNN technique. In the vGGface2 based methodology, enormous face dataset has been presented with the target of having bigger number of personality with more number of pictures for every character, name clamor minimization with the inclusion of posture, age and nationality. Preparing of face is executed by ResNet-50. Examination between the VGG face2 and MSceleb-1M dataset based acknowledgment acknowledged shows improved execution for VGGface2. Examination showed and proposed execution improvement with IJB-An and IJB-B face acknowledgment benchmarks [15]. Face likeness is estimated by utilizing FaceNet model, gives 99.63% precision which is caught utilizing LFW dataset and 95.12% accomplished utilizing YouTube Faces DB. Profound CNN strategy in [17] is utilized for face location and acknowledgment. The acknowledgment framework incorporates FaceNet CNN, Face tourist spots and face installing and SVM classifier with exactness 95.02%. Essentially in [18], proposes a video based FR framework with 99% precision on 82 understudies, each having 32 face pictures. Profound learning dependent on improved AlexNet CNN model [19] proposed an acknowledgment pace of around over 80%. It gives better component extraction. WebFace informational collection is utilized to improve preparing of organization and test. The paper proposes face fantasy (FH) and acknowledgment framework [20] utilizing generative antagonistic organization in which face mental trip remake a high goal picture from a low goal picture and acknowledgment can be precisely done by the limited picture. The examination proposes two models, first FH-GAN network which has improved face pipedream and acknowledgment together. Second is another mind flight organization, thick inadequate organization which was actualized mutually with DSNNet for better outcome. The dataset utilized in this proposed work are LFW for testing the exhibition of face mental trip and furthermore for checking the exactness of face acknowledgment.

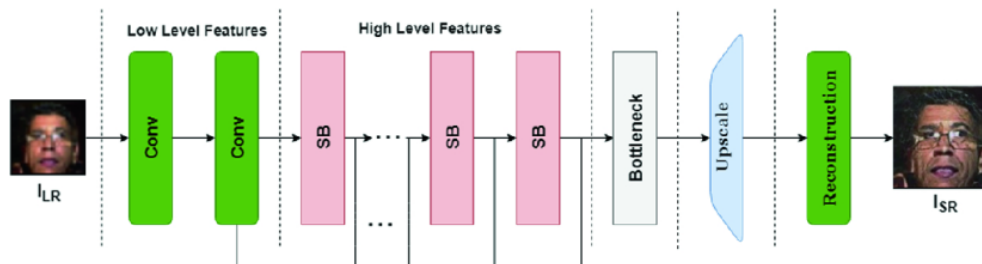


Figure 2: FH-GAN design

A calculation for face verification with unconstrained condition (UC), in view of profound convolutional highlights is proposed and assessment done in IARPA Janus Benchmark A (IJB-A) dataset and Wild (LFW) dataset in [21]. The IJB-A dataset incorporates 500 subjects with posture and brightening varieties. The CASIA-WebFace dataset is utilized to prepare profound convolutional neural organization (DCNN). Milestone location is done prior to preprocessing, as it gives better execution on unconstrained faces which was trailed by face arrangement. Bayesian Metric learning is proposed for utilizing positive and negative picture in the preparation set. This has upgraded the exhibition of face check (FV). For the assessment of calculation, total match attributes scores and collector working trademark bend has been utilized.

E. Standard Dataset used in the reviewed paper with Key Features

Table 1: Standard dataset used

Dataset	Image	Subjects (S)	Image(I) used	Key Features
VGGface2	2.3M	8400	1.0M	8631 S Pose, age, ethnicity
[20] CASIA-WebFace	4,66653	10,575	Less than 450K	Celebrity
CFP[20]	5000	300	-	Used for FV
LFW[20]	12433	7542	-	Testing FV &FH
JANUS CS2 (IJB-A)[20]	5397 images	450	5397 Images	V split into 167
MSceleb-1 M [15]	6M	90	-	Celebrity
[13] Yale database	120	12	10 image	8 image per subject for expression or lighting.

3. Face Recognition Using Periocular Region

Face picture is the main piece of a human body conveying highlights that are one of a kind to an individual. Face picture additionally gives data about an individual's sex, identity, age. Thus face biometric has been broadly utilized by the scientists for individual validation, just as for identity, sexual orientation, and age characterization. Anyway enormous format size makes facial acknowledgment/grouping framework delayed in down to earth huge data set situation. Subsequently to provide food for the need of ongoing application, periocular district: a possible subset of face has acquired its significance as opposed to utilizing the full face picture. Both acknowledgment also, arrangement frameworks utilizing periocular picture are proposed by different scientists. While acknowledgment or characterization through periocular district, roughly 25% of the entire face

picture is utilized. It implies that the greater part of the huge facial highlights of face are dense into periocular area, which further accentuates the significance of considering periocular district for order/acknowledgment. Subsequently periocular biometric can likewise be utilized as added data to confront information utilized for grouping [4], costing no additional different time and exertion for procurement, and no extra for extra room. In any case, if periocular district is sent in a free biometric framework, at that point the every format size will be decreased to roughly 25% of the current face format size. This attaches the distinguishing proof method of acknowledgment, when the data set size is as huge a country.

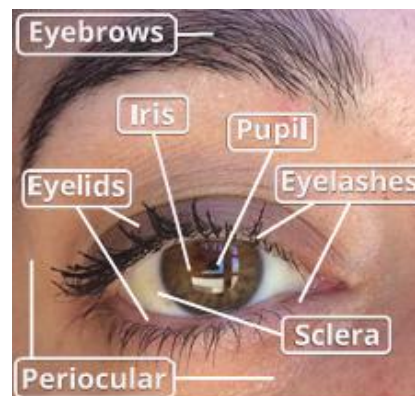


Figure 1: Ocular components



Figure 2: UBIRIS.v2 [27]: uncontrolled environment images at visible wavelength (left) and CASIA-IrisV4-Thousand [28]: controlled environment images at near-infrared wavelength (right).

Right now, there are different data sets of visual pictures, built in various situations and for various purposes. These information bases can be arranged by VIS and NIR pictures and isolated into con-savaged (cooperatives) and uncontrolled (non-cooperatives) environments, as indicated by the cycle of picture obtaining. Controlled data sets contain pictures caught in conditions with controlled conditions, for example, lighting, distance, and core interest.

Then again, uncontrolled information bases are made out of pictures got in uncon-savaged conditions and normally present issues, for example, defocus, impediment, reflection, off-point, to refer to a couple. An information base containing pictures caught at various frequencies is alluded to as cross-otherworldly, while a data set with pictures obtained by various sensors is alluded to as cross-sensor. The rundown of all data sets referred to in this paper just as connections to discover more data about how they are accessible can be found at [www.inf.ufpr.br/vri/distributions/ocularDatabases.html].

3.1 Periocular biometrics in smart phone authentication

Periocular biometrics additionally assumed a significant part in advanced mobile phone confirmation as summed up in Table 8. Ahuja et al. (2018) proposed a two-venture AI calculation for client confirmation on cell phone. In the main period of the calculation they prepared a multinomial innocent bayes classifier utilizing SURF highlights extricated from nearby eye locale and acquired an exactness of 64.96%. While in the subsequent stage, they made a pyramid of top k% highlights from the primary stage and actualized Dense SIFT calculation for closest neighbor coordinating. They got 79.49% precision, most elevated as contrast with other best in class methods. They additionally investigated the effect of profound learning on Smartphone validation (Ahuja et al., 2017) in periocular biometrics. With a similar arrangement as in Ahuja et al. (2019) they set forward a blend of managed and unaided convolution-based model with ROOT filter for recognizable proof and acquired a precision of 99.5%, which shows the capability of the above technique, all things considered, situation. Bakshi et al. (2018) exhibited the viability of Phase Intensive Local Pattern (PILP) in cell phone biometrics utilizing Reduced-PILP. For lessening the list of capabilities they orchestrated all stage serious nearby examples (Bakshi et. al., (2019) in a succession from generally important to least huge and prune least huge highlights. In this investigation they saw that greatest 20% of the decrease in highlights gives same precision as entire list of capabilities however speeded up the coordinating time by the factor of 1.56.

3.2 Periocular biometrics in soft biometric classification

Delicate biometrics comprises of number of biometric characteristics like sexual orientation, race, nationality, age, stature and weight which can't be one of a kind for an individual yet may uphold other biometric qualities for ID and confirmation and can improve the acknowledgment precision of any biometric framework. In writing, periocular biometry is fundamentally utilized for sexual orientation, nationality and race grouping and SVM as a classifier is consider as a decent decision for delicate biometric characterization. Chen et al. (2018) completed a trial for Race characterization utilizing periocular locale pictures. They centered to order East Asian from Caucasian (the other way around) and utilized five neighborhood highlights 1) surface of tear channel area 2) surface of the locale between upper eyelid and eyebrow 3) shade of iris 4) force in upper district of internal eye corner and 5) distance between upper eyelid and eyebrow. To separate the nearby highlights first they utilized STASM strategy for programmed milestone

recognition, at that point LBP for textural include extraction and got 97.45% race grouping exactness with KNN classifier. They likewise got acknowledgment pace of 98.15% for same sex pictures and 93.4% when subject are wearing glasses.

3.3 Face pictures got when plastic operation

Jillela and Ross (2018) developed a strategy to organize pictures got when plastic operation of face. Face features were isolated using Verilook and PitPatt programming and SIFT, LBP incorporate descriptors were used for visual region. Resulting to entwining the score got by both the modalities (face and visual) they got rank1 affirmation exactness of 87.4% which is most raised diverged from other uncovered works in existing composition for plastic operation data base.

3.4 Periocular pictures got when plastic operation

Raja et al. (2016b) investigate the introduction of periocular biometrics for the photos got when plastic operation of nearby region of eyes. They made an informational index SAPID informational index, applied a couple of shape and surface part descriptors and procured position 1 distinctive confirmation speed of 53.73%. Considering the lower ID accuracy they contemplated that cautious changes corrupt the display of periocular biometrics and this district needs further investigation.

3.5 Periocular pictures obtained when operation cascade

Keshari et al. (2016) executed the possibility of periocular biometrics for organizing the photos got when operation of regular eyes cascade. They made scat net segment descriptor and obtained nearby 30% affirmation accuracy. The yield shows the need of extra examination in this field.

3.6 Face pictures gained when sex change

Mahalingam et al. (2018) assembled more than 1.2 million face pictures from you tube chronicles of 38 subjects (who were experiencing sex change). They arranged those accounts throughout a period of some time to three years and made HRT-Transgender dataset (Mahalingam and Ricanek 2017). They inspect and consider the organizing precision of face and periocular region based biometric affirmation in an especially non-ideal circumstance and uncovered the way that periocular zone with clear surface based component descriptor (LBP, HOG and fix baseed neighborhood twofold models) achieved higher affirmation speed of 57.79% as differentiation with full face check structure which was simply refined 46.39% affirmation exactness in a comparative circumstance sex, race, ethnicity, age, height and weight which can't be novel for an individual yet may maintain other biometric attributes for recognizing evidence and affirmation and can improve the affirmation precision of any biometric system. Recorded as a hard copy, periocular biometry is fundamentally used for sex, personality and race request and SVM as a classifier is consider as a respectable choice for fragile biometric portrayal. Table 9 format the introduction of periocular biometrics in fragile biometric gathering. Chen et al. (2018) did a test for Race course of

action using periocular territory pictures. They focused to arrange East Asian from Caucasian (the reverse way around) and used five close by features 1) surface of tear pipe region 2) surface of the region between upper eyelid and eyebrow 3) shade of iris 4) power in upper region of internal eye corner and 5) distance between upper eyelid and eyebrow. To remove the area incorporates first they used STASM procedure for customized achievement revelation, by then LBP for textural feature extraction and gained 97.45% race portrayal precision with KNN classifier. They furthermore got affirmation speed of 98.15% for same sex pictures and 93.4% when subject are wearing glasses.

4. Advantages and Disadvantages of Various Detection Method

1) HAAR CASCADE

Advantages:

- Simple architecture
- Possible to detect faces at different scales.

Disadvantages:

- Not detecting the face in the image for non- frontal conditions.

2) DNN Face Detection

Advantages

- Detection is possible at non formal condition
- Possible to detect faces at different scales

Disadvantages

- Not detecting the face in the image for non-frontal conditions.

3) Histogram Of Oriented Gradient

Advantages

- Fastest method when used in CPU.
- Possible to detect frontal and slightly non frontal face.

Disadvantages

- Side face is not detected which is extreme, non-frontal
- Face size more than 80*90 is not detected.

4) CNN Face Detection

Advantages

- Perform detection if frontal and non – frontal faces.
- Training process is fast
- Faster face detection with GPU compared with CPU

Disadvantages

- Face size more than 80*80 is not detected.
- Slower face detection with CPU compared with GPU

5) YOLO V3 Face Detection

Advantages

- Smaller face image can also be detected
- Fast and Good for real time processing

- Better accuracy
- Frontal and side wise face is also detected.

Disadvantages

Difficult to implement using Raspberry – pi.

5. Conclusion & Future Scope

The essential goal of this paper is to give an informative perspective on periocular biometrics writing and about what highlights, include extraction techniques and coordinating plans are as of now investigated and what issues are staying to be neglected in this field. With the quickly developing mechanical world, it is important that the framework utilized for ID and confirmation of the people should request less client collaboration and periocular biometrics is an awesome answer for this issue. Periocular district can be considered as an exceptionally encouraging quality both as a solitary methodology also, as a help for face and iris biometric. Periocular district accomplished better outcome by and large where face biometric endures from various limitations like posture, enlightenment variety, impediment and maturing impact. Combination of iris and periocular region moreover accomplished better outcomes when contrasted with iris as an independent methodology. More over iris biometrics requires high client participation and it needs pictures caught in NIR Spectrum. Rather than this, periocular biometric doesn't need exceptionally high client collaboration and function admirably with the pictures caught in obvious range and in wild. This paper additionally exhibits the significance of periocular biometry in some unique situations like delicate biometric order (order of Gender, Race and identity) and acknowledgment of restoratively modified countenances (Transgender, waterfall medical procedure) and demonstrated that periocular district is one of the promising attributes for biometric verification frameworks.

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