RESEARCH ARTICLE

FACE RECOGNITION: LITERATURE REVIEW.

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Manuscript Info	*Abstract*
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	Face identification is one of the most developing research zones because of increasing demands for security in numerous applications. This paper provides the brief review on two-dimensional (2D) and 3D images under visible spectra of face recognition techniques. Moreover, the advancement in infrared (IR) for face recognition is also highlighted.

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Introduction:-

The way toward recognizing people in the light of their facial features is known as face recognition. It winds up noticeably a standout amongst the most prominent research areas such as machine learning, computer vision, and pattern recognition. The most common reason behind increasing demand of face recognition is its various latest facial based applications, such as surveillance, access control, credit-card verification, mug shot searching, criminal identification and security of computer systems [1]. Additionally, face recognition have been introduced in context aware based applications which provides a natural visual interface for various gadgets such as smart TV, video and music players [2][3].

Basically the process of face recognition techniques based on two major parts i.e. face detection and face identification. On the basis of these two parts, the techniques are classified as fully automatic (consists on both parts) and partially automatic (consist of only the second part).

There are distinctive strategies for recognizing faces like verification or identification. In verification, the target face is compared against a set of faces of similar target. In identification, a target face is compared against each face in a data base. Three imperative criteria choose the viability of face recognition technique. Firstly, the representation scheme if images for extracting useful data. Secondly, Issues related to difference among pose or facial orientation and thirdly, the extracted data is calculated into a statistical shape and performed proper analysis.

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Face recognition based applications are embedded on biometric devices. In general operation of these devices is based on three step procedure. First, a sensor is utilized to captures an observation which provide a "Biometric Signature". The type of sensor and its observation totally relay on the biometric gadgets. Second, a computer based calculation or algorithm which normalizes the captured biometric signature into the same format (size, resolution, view, etc.) as the signatures on the system's database. Third, a machine learning based matcher is used to compare the normalized signature with the set (or sub-set) of normalized signatures on the system's database and at last calculate the similarity score.

Applications:-
Various fields are come up with face recognition based applications which are discussed below one by one.
- **Face ID:** instead of traditional key and password based identification is replaced with identify people by their face images, it also ensure the physical presence of an authorized person. Such applications are Driver licenses, entitlement programs, immigration, national ID, passports, voter registration, and welfare registration.
- **Access Control:** the access and restriction to a place or resource is control in this field. Face recognition applies on numerous areas for example: Border-crossing control, facility access, vehicle access, ATM, computer, program, database, network access, online transactions, long distance education and online examinations.
- **Security:** The face recognition secure the number of systems from life threading damage such as terrorist identification, flight boarding, stadium, audience scanning, computer based application i.e. database, file encryption, Internet, medical records, and trading terminals security.
- **Surveillance:** numbers of advanced surveillance applications are implemented on different locations such as park, neighbor, power grid, patrol control, nuclear plant to secure the public.
- **Law enforcement:** this area covers the crime stopping and suspect alert, tracking, suspect background checking, investigation, identifying fraud and cheats and etc.
- **Human computer interaction (HCI):** Intelligent gaming and proactive processing are the examples in HCI class. Other than this, antique photo verification, low bit rate video and image transmission and so on are some advance applications of face recognition systems.

Face Recognition Techniques:-
As a standout amongst the most famous biometric traits, face provides clear favorable circumstances of being common and easily available biometric trait as compare to unique mark traits. To take advantages of facial based identification, a framework should have the capacity to distinguish an uncooperative face in uncontrolled condition and a discretionary circumstance without notice of the subject. In this section, the recent research in face recognition has been overviewed that apply mostly to frontal faces.

I.   **Local binary pattern LBP**
In this technique, the face picture is partitioned into the areas (pieces) and every district relates with every focal pixel.

At that point it inspects its pixel neighbor in view of the dark scales estimation of focal pixel to change its neighbor to 0 or 1 [4]. Later on extended LBP operator in the view of Weber's law was proposed [5]. A new bit of knowledge into three dynamics regarding iris location method on K-means algorithm; Sobel and LBP methods was introduced [6]. Another LBP based approach in face recognition applies form the perspective of various lighting conditions. In this scheme Difference of Gaussian (DoG) and LBPs has been utilized to extract the images for recognition [7].

Ahonen etal. [8] connected nearby paired example of local binary patterns [9]. This new method was extracted by binarising the gradients of centre point. Moreover, the sub-division has been applied on several parts of face image. The approach proved more robust in pose and illumination changes because of its versatile abilities [10].

II.   **Principal Component Analysis PCA or Eigenfaces:**
To deal with face recognition, eigenface is one of a very famous approach. Another name of this approach is also known as Karhunen- Loève expansion, eigenpicture, eigenvector, and principal component. Principal component analysis (PCA) technique is totally based on lower dimensions. In this method a statistical calculation is applied which converts the maximum number of co-related variables into a smaller no. of uncorrelated variables [11]. The

fruitful use of PCA was analyzed effectively on face representations [12, 13]. The advance method known as D2D-PCA was proposed specifically to overcome illumination changes which normally a main issue in face recognition system. The approach was based on new feature and a fusion of two half-face images [14]. Singular Value Decomposition was utilized to manage encompassing light. The wavelets have been employed to combine KPCA for Multi Scale Features [15, 16].

In [17], the authors utilized sparse representation in alignment step to test face image. Another approach of eigenfaces was adopted which was inspired by the procedure of Kirby and Sirovich [18]. The covariance matrix based approach has been utilized to compute three images with different lighting effects and extend their work on face components [19, 20]. Later on a multimodal based identification system combined face and fingerprint along with the voice of the subjects [21].

III. Neural network:
The non-linearity of neural network makes it more famous and attractive in various field of image processing. It is very tricky to design and implement of a neural network based recognition successfully. Its criticalness totally depends on future application. Neural network have been applied for face detection, multilayer perceptron and convolution. In face verification system multi-resolution pyramid structure has been implemented [22]. Moreover, a hybrid approach of neural network was proposed in which local image sample, a self organizing map and convolutional network [23]. Another approach based of probabilistic decision based neural network (PDBNN) has been applied. The approach inherited the modular structure from its predecessor, a decision based neural network (DBNN) [24]. The extended version of NN from the multi-view face representation was adopted via multiband feature technique [25].

A systolic architecture has been introduced for large scale based integration of face recognition. A hierarchical method of decision-based neural networks DBNN was adopted with the combination of nonlinear basis functions and a competitive credit-assignment scheme [26, 27]. A contrast adjustment based technique for face recognition has been introduced. The correlation and statistical independence functions were used to set the parameter problems.

IV. Hidden Markov Models (HMMs)
The HMM based Stochastic modeling of non-stationary vector time series has been proved effective for speech based applications. Recently, this new dimension references in human face recognition [28]. one way to associate and apply HMM was to divide the face regions such as eyes, nose and mouth etc. while in a spatial based observation sequence a band sampling were adopted for face images [29].

V. Template Matching
Various methods have been proposed in the literature for template matching.

The Euclidean distance has been adopted for template matching. In which the whole image was represented in the intensity values of a two-dimensional array and compared via approximate metric [30].

Recently, form the distinctive viewpoints the face template were compared of an individual. While from single view point but multiple distinctive smaller templates have been adopted for face recognition. Furthermore, the different parts of the template were utilized for matching such as eyes, nose and mouth. The main limitation appeared in template matching is computational complexity [31, 32]. In general, it is more logical as compared to feature matching based approaches for face recognition.

VI. Wavelet transform:
Generally believed that neighborhood based features are more reliable while spatial frequency analysis concentrate such features [33, 34]. In this regards wavelet is most popular tool used in characteristics of space–frequency localization [35]. The wavelet transfom based face recognition technique has been proposed by calculating the shape and texture of the face images [36]. Moreover, discrete wavelet transform based scheme was introduced via probability distribution functions through various color channels. Specifically, among different wavelet bases Gabor functions provide the higher resolution in spatial and frequency domains [37, 38]. A Gabor based dynamic link framework and other advance techniques were proposed for face recognition [39, 40, 41, 42, 43].   Later on, the DT-CWT and ST-CWT based face recognition performed better than Gabor wavelets [44,45,46].

VII. **Multi algorithm approach:**
Nowadays, most of the research is focusing on mutli-modeling and multi-algorithm techniques. In this approach more than one technique are combined to extract features from different perspective in face images. The four kind of schemes like principal component analysis (PCA), Discrete Cosine Transform (DCT), Template Matching using Correlation (Corr) and Partitioned Iterative Function System (PIFS) have been implemented in multi algorithm approach [47]. Along with the multi-algorithm, multi biometric was introduced via merging gray level correlation ann principle component analysis (PCA) [48, 49].

VIII.   **3D model**
The utilization of 3D data in face recognition has recently been pulling in consistently expanding levels of consideration in the biometric group. The reflected light caught by the camera is a complex capacity of the surface geometry, albedo, brightening and the spatial characteristics.

The use of 3D information in face recognition has lately been attracting ever increasing levels of attention in the biometrics community. The reflected light captured by the camera is a complex function of the surface geometry, albedo, illumination and the spectral characteristics of the camera. The unique way to deal with these issues of face recognition is come up with 3D properties based approaches [50]. Along with the 3D geometry a multiple texture maps was adopted to detect the parts and then align model which cover wide range of pose and appreances [51].

IX. **Biomechanical models**.
 In this approach, the structure and musculature of the face is used mostly for computer animation based applications. Biomechanical model based on 3D shape and color, biomechanical properties of skin and structure beneath the skin and anthropometric statistics along with natural changes in facial appearances adopted to combine 3D and 2D data of face images and proof the success in recognizing the faces.[52, 53].

X. **Infrared**
Infrared image or thermal images or thermograms shows the heat discharged from an object. These thermal changes represent uniqueness of every object according to their different characteristic of material and its temperature. Thermal imaging becomes more popular in face recognition field via analyzing the temperature generated by blood vessels under the facial skin [54]. Hence, for thermal based face verification systems, particular kind of sensor or camera known as IR is utilized to capture the images which show the thermal changes among faces of various skin types and colors. NIR spectrum has been powerfully provide a detection rate for faces and adopted in numerous face recognition systems via computing feature extraction technique on thermal images [55, 56, 57, 58 and 59].

Conclusion:-
This paper provided a brief review of the active research of face recognition. It is observed that face recognition is a dynamic field because of its potential use in wide range of applications from commercial to private and from government to public sector. In this paper the advances in face recognitions techniques and major efforts are covered and highlighted the latest trends in face recognition techniques for future references.

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