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Designing Face Recognition Model under Illumination Variation

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Abstract: Human faces exhibit the characteristic that can be used for identity of an individual. As a result, face recognition technology can be used for verification and identification purpose. There are various face recognition algorithms available for the same. However, illumination variation in face recognition is still a challenge. In this paper, a method for face recognition is presented which gives considerably better result in the presence of illumination effect. The proposed work consists of three major phases as face detection using Violo-Jones, feature extraction using LBP and classification using SVM. For experimental analysis the Yale face database has been used which consists of 165 images of 15 different subjects.

Keywords — Face recognition, Face detection, Local Binary Pattern (LBP), Support Vector Machine (SVM).

I. INTRODUCTION

Face Recognition is one method for recognizing the individuals in light of the fact that the face is an interesting human part. Face recognition called biometric systems that naturally distinguishes or checks an individual's character utilizing his/her facial highlights and looks. It is generally used to distinguish international IDs and driver's licenses conveying people regardless of whether they don't know that a face recognition system is self- sufficiently checking their personality [2, 3]. Face recognition programming has numerous application in the advanced world, for example, signing in on to a PC utilizing facial check as a secret phrase, gaming, individuals labeling, security *etc.*, [4]. One of the most important challenges related to the face is that to detect the face in video surveillance. Sometimes, the face we have detected having very poor quality or it has been partially occluded by the light, beard and the glass. So, due to which the accuracy of the system gets degraded [26]. The present FRS and applications in the market have limitations that run from unwavering quality issues, diminished recognition exactnesses in a certain condition, muddled component extraction, high setup expenses, and execution issues. Nonetheless, the interest for a strong FRS appropriate crosswise over different mechanical utilizations, associations and the open is expanding significantly. The face recognition algorithm consists of three main parts: face detection, feature extraction and Matching.

i) Face detection: To detect the facial part of the image Viola Jones algorithm [2] has been used for the input image.

ii) Feature Extraction: The detected facial image has been used for feature extraction technique. We have used LBP feature extraction techniques. LBP works on 3×3 window contains center pixel is considered as threshold value and 8 neighboring pixel values to obtain the feature.

iii) Matching: The features of the test images are compare with the stored database train image features by using multiclass Support Vector Machine (SVM).

This paper presents a Local Binary Pattern (LBP) based feature extraction for illuminated facial images. LBP works on 3×3 window face image to obtain the final features of the image. Once the LBP features are extracted, SVM has been used for the purpose of face recognition purpose. The overall performance of the proposed work is evaluated through recognition rate. In rest of the paper, section II presents the literature review of existing work and section III presents the architecture of proposed work followed by section IV that discusses the experimental setup and results. Finally, section V concludes the proposed work presented in the paper.

II. LITERATURE REVIEW

This section presents the review of work presented in the past years based on illumination invariant face recognition. In paper [1], authors have proposed a method in which there is no loss of features from the image due to a proper selection of illumination normalization technique for illumination compensation. Moreover, it also saves the processing time for illumination normalization process when an image is classified as normal. Further, the authors in [2] proposed FR technique by utilizing the features of extended LBP. Also, they have used SVM classification for FERET and Yale face database. The authors used parameters such as FAR, FRR, TSR and EER for performance evaluation.

The system proposed in [2] consists of the face image acquisition, pre-possessing such as gray conversion, face

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region extraction, resizing the face region, feature extraction, classification and matching. The performance results are better for Yale database compared to FERET database. Authors Seong G. Kong, Jingu Heo, Besma R.

Abidi, Joonki Paik, and Mongi A. Abidi in paper

[3] presented an up-to-date review of research efforts in FR techniques based on (2D) images in the visual and infrared (IR) spectra. They also stated that unlike other biometric identification systems based on physiological characteristics, FR is a passive, non-intrusive system for verifying personal identity in a user-friendly way without having to interrupt user activity. Later, in paper [4] authors Timo Ahonen, Abdenour Hadid, and Matti Pietikainen, proposed efficient facial image representation based on local binary pattern (LBP) texture features. In their proposed work the face image has been divided into several regions from which the LBP feature distributions are extracted and concatenated into an enhanced feature vector to be used as a face descriptor. The performance of the proposed method has been assessed in the FR problem under different challenges.

In the paper [5] authors M Shujah Islam Sameem, Tehreem Qasim, Khush Bakhat proposed efficient face detection and recognition system. This proposed work has the capability to recognize human faces in single as well as multiple face images in a database in real time. For FR they have performed face matching using putative matching and, outlier removal using MSAC algorithm. This system is capable of handling images in real time. Use of LBP to tackle face recognition has been presented in [7]. In this paper, LBP has been used for feature extraction and applications related to the facial image analysis have been discussed. Authors Y. Freund and R. E. Schapire in paper [15] present a strategy to develop a composite feature vector to use all points of interest of different kinds of features for the FR. No specific feature extraction technique dependably outflanks different ones. Different sorts of all holistic and nearby features have their very own qualities in perceiving faces, and yet, every one of them may display distinctive shortcomings relying upon the kind of varieties which makes FR difficult. Author Ashwin Khadatkar, Roshni Khedgaonkar, K.S.Patnaik [16] proposed two algorithms based on occlusion detection phase and MBWM based face recognition. The author has worked on partially occluded face images. The performance of the proposed method is carried out by using near set theory.

Authors X. Xie *et. al.*, in [26] proposed different approaches for illumination preprocessing technique and grouped into three categories. There are 12 illumination preprocessing approaches based on six face matching methods that are performed by using four public face databases. Another issue that exists in illumination preprocessing approach is that the method that based on reflectance field estimation and it delete the large scale band in illumination preprocessing. Due to which the face shading information is lost in the preprocessed image and it seem to be flattened. Further, the authors in [27] proposed that feature in large-scale band gives benefits for lighting-insensitive face recognition. It provides method based on facial reflectance field estimation such as SSR, GHP and SQL for integrating the large-scale and small-scale bands. Authors Rafael C. Gonzalez and R. E. Woods proposed the efficient method for illumination variation for better performance. In this paper, discrete Fourier transforms (DFT) and Local Binary Pattern (LBP based method used for illumination compensation in the transform domain. During the analysis of the Fourier transform, the magnitude component of the frequency coefficients in the transform domain under illumination are enlarged [28]. H. Yujie, L. Jie, Y. Shi [29] had proposed the robust approach for face recognition under illumination variation where they fused combination multi-condition relighting and optimal feature selection. Firstly the multi-condition relighting provides a "coarse" compensation for the variable illumination, and then the optimal feature selection further refines the compensation. It additionally offers the robustness to shadow and highlight, by deemphasizing the local mismatches caused by imprecise lighting compensation, shadow or highlight on recognition. It is a difficult task to improve the performance of face recognition under various illumination conditions. The author proposed in paper [29] is that Estimation-based illumination invariant extraction is widely used for reducing effects of illumination on face recognition. To alleviate inaccurate illumination, they proposed directional illumination estimation technique to extract invariant sets of directional illumination from face by using Lambertian reflectance model. The directional illumination invariant sets not only better preserve essential features of the face, but also largely reduce the adverse effects of rapid light changes. Some research on the condition when there are multiple lights which simulate continuously and rapidly varying illuminations. This scene can be seen not only in doors or in the dark or in underground architecture but also out doors or in the light. Y. Guo, B. Yang, Y. Ming, A. Men proposed a new illumination factor algorithm which can be applied for both the indoor environment and outdoors with natural illumination in which illumination factor is computed by comparing background and the current frame. The background estimation and updating is done on the basis of computed factor, which tracks the change of background accurately and reduces the error [30].

III. SYSTEM ARCHITECTURE

A. System Architecture

In the proposed work, the first task is face detection because it determines the person face for face recognition. The system architecture of the proposed work is depicted in figure 1 consisting of the different modules.

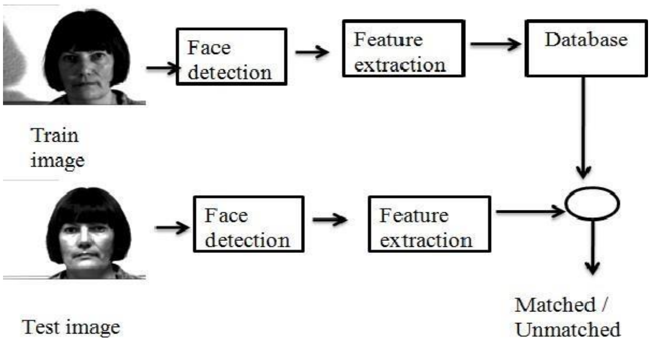

Fig. 1 System Flow

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Face detection: Initially, face is detected from an input image using Viola-Jones algorithm [2]. The Viola Jones algorithm is used to extract the face portion from the grayscale image. The detected face parts of subject 11 from Yale database is shown in figure 2. After detection, the face part has been cropped and detected face of the same subject number 11 considered as an example is shown in figure 3.

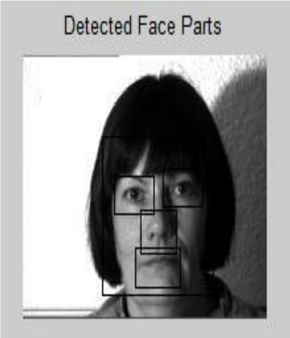

Fig. 2 Detected Face Parts of subject 11

Fig. 3 Detected faces of subject number 11

i) Feature extraction: After the face is detected from the input image, the most useful information from the face has been extracted by using LBP. For each pixel, LBP is calculated and texture features are extracted. The texture features are called as histogram. The histogram for each region is separately calculated. Now, the histograms are concatenated to form a global region. This histogram has been considered as a feature vector of the LBP.

Local Binary Pattern

Local Binary Pattern (LBP) is a robust method for texture descriptor. The Local binary pattern is invariant to monotonic grayscale variation and it is efficient for local feature extraction technique which determines the information about the shape and texture of the face image [17]. LBP operator work on 3×3 window where center pixel value is considered as threshold value and surrounding eight neighboring pixel value is compared with the center pixel and the output is in binary form.

$$S(x) = \begin{cases} 1, & x \geq 0 \\ 0, & x < 0 \end{cases} \quad (1)$$

Where,

$$LBP(P,R) = \sum_{P=0}^{7} S(g_p - g_c)\, 2^P \quad (2)$$

g_p = gray value of the center pixel
g_c = value of the neighboring pixels

P = Number of neighbors

R = Radius of the neighbors

In figure 4, there are eight neighbors and a center pixel. Now, the neighboring pixel value is compared with the center pixel value. The binary value 1 is generated if neighboring pixel value is greater than the center pixel value. If the neighboring pixel value is greater than the threshold value, it gets the binary value as 1 for that pixels, otherwise, it gets the binary value 0.

The binary value is converted into its equivalent decimal value. The decimal value is considered as a LBP feature. For each pixel value LBP features are extracted. This LBP feature is used for the matching process. Otherwise, it generates the binary value as 0.

When the binary value generated for all the neighbors, the resulting binary value obtained is 11011001. The binary value acts like a mask to extract the local feature from the image. The obtained local texture features from the image acts robust against illumination variation. To obtain the final LBP feature for the 3×3 sub-block, the binary pattern is converted into its decimal value, *i.e.*, 217. The local binary pattern is called as a uniform LBP if at most two bitwise transitions from 0 to 1 or vice versa. The figure 4 demonstrates the illustration of the LBP operator.

55	78	19
90	40	64
38	26	89

⇨

1	1	0
1		1
0	0	1

Binary value:
11011001
Decimal value:
216

Fig. 4 LBP Operator

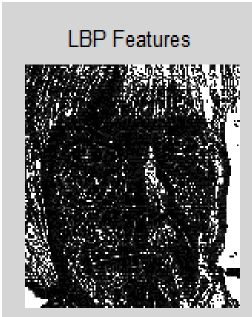

Fig. 5 LBP Features of subject number 11

The figure 5 depicts the LBP features of the subject number 11 under consideration. The bright spot indicates that the useful information can be extracted. The black spot indicates that no useful information can be extracted. LBP works on its relative neighbors.

ii) Matching: During the matching process, LBP features are extracted for the test image and the matching is done with the train image by using multiclass Support Vector Machine (SVM). SVM is used for recognizing the faces on the basis of the supervised learning. SVM is used for separating the hyper plane. The feature vector that obtained near the hyper plane that helps in classification process.

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SVM can support binary as well as multiclass classification.

The figure 2 is the detected face part of the test image of subject number 11 is matched with the database train image of the same subject number 11 as shown in figure 6. The recognition can be done by using the multiclass SVM.

Fig. 6 Train image of subject number 11

IV. RESULT AND DISCUSSIONS

This section of the paper presents the description of the database used for experimentation followed by the setup used for experimentation. Finally, the results are presented.

A. Dataset Description

To effectively analyze the results of the proposed system rigorous experiment has been done using Yale Database [6]. It is a well-known database that covers various characteristics specifically used for face recognition. Yale database contains 45 images of 10 different subjects having various illumination effects. The dataset is categorized as subject 1, subject 2, subject 3, subject 4 and subject 5 and so on as per the varied level of illumination effect. We have used 25 input images for training and 18 images for testing purpose.

All the experimental cases are implemented in MATLAB in congestion with algorithms and strategies, and the competing face recognition approach along with LBP feature extraction technique, and runs in the environment with System is having configuration of Intel Core i5-6200U, 2.30 GHz Windows 10 (64 bit) machine with 8GB of RAM.

B. Experimental Setup

Firstly, the input image has been taken from a Yale database, in which there are total 165 images. Few of the sample images from Yale face database has been depicted in figure 7.

We have taken only 24 input images for feature extractions. There are total 24 input images in which images are taken in different lighting conditions such as center-light (the light focus on the center of the face), left-light (light focus on the left part of the face), right-light (the light focus on the right part of the face), happy (when person's is smiling), sad (when the person's mood is bad), winks and surprised (when a person got unexpected result). Faces with varying conditions as discussed above are shown in figure 8.

Fig. 7 Sample images from Yale database.

C. Results

After the input image has been taken, the next phase is to detect the facial portion from the input image of the subject. In the detection phase, the box appears on the face image such as box for left eye, right eye, mouth and last the box that covers all the facial parts. The figure 9 shows the resultant output of detected face portion from the samples from Yale database. After detecting the facial parts of the person from the input image, the face has been cropped from the rest of the input image. The advantage of this step is that, it eliminates the unwanted information that can act as noise during feature extraction.

Detection of specific facial portion helps in overcoming this noise and irrelevant information. The figure 10 shows the output of detected faces from the Yale face database.

LBP operation is further applied to the detected facial image for feature extraction. Now, the features should be extracted from the image as shown in the figure 11. The output of Local Binary Pattern (LBP) is in gray scale form. The bright spot indicates that there are relevant features robust to illumination which can be further used for matching purpose. The dark spot or lower values of gray scale indicate absence of relevant features that can be used for matching.

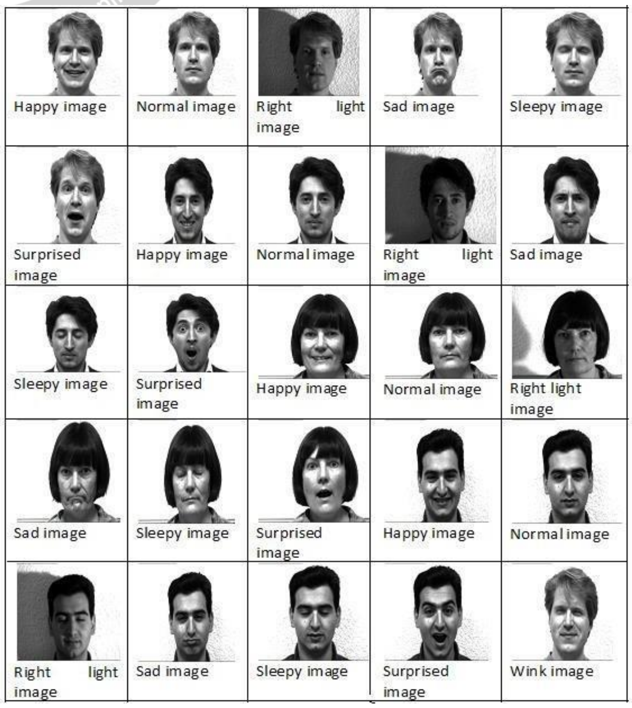

Fig. 8 Sample input images from Yale database

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Fig. 9 Output showing detecting face parts from Yale database

Fig. 10 Output for LBP features from Yale database

As shown in the table 1, there are total 256 feature vector out of which further only 35 features are extracted. . The 35 features extracted from column 3 are 177, 1353, 829, 172, 11168, 3, 33, 24, 23955,

397, 62, 10, 347, 74, 16, 317, 0, 86, 128, 2929, 17,

2, 7693, 64, 44, 26908, 12039, 61, 0, 77, 5, 0, 53,

17, 829.In the column 3, the value 0 indicates that there is no feature in the face that is relevant.

The integer values consist of 2 digit values, 3 digit values, 4 digit values and 5 digit values. These digits indicate that the number of counts of pixels. The computation of 11168 is that number of counts of pixel in the image. Similarly, the computations of the other digits are also same.Once the LBP features are extracted, the SVM algorithm is used for recognition of the faces so as to find the match. Figure 12 shows the matched train facial images for few of the test samples from the Yale database.

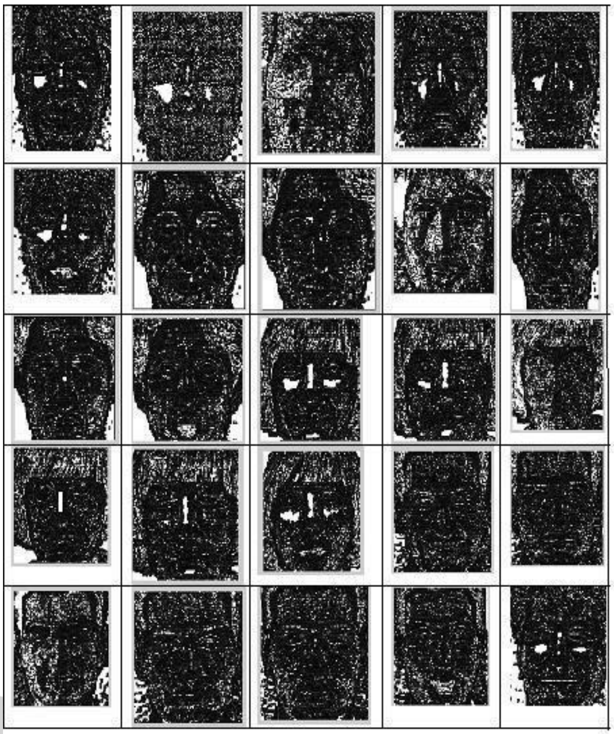

Fig. 11 Output for LBP features from Yale database Table 1:

Representation of feature vector of the input image

	1	2	3	4	5	6	7	8	9	10
1	233	3855	177	276	343	91	93	62	102	65
2	1479	7207	1383	1869	1486	1781	801	788	808	677
3	1455	4594	829	1450	1295	1564	578	167	390	691
4	215	760	172	233	240	240	101	96	71	107
5	11832	14806	11168	11826	11624	12730	8347	8430	8107	9096
6	2	174	3	3	3	5	0	0	0	0
7	71	234	33	62	54	73	17	12	10	18
8	55	224	24	54	51	72	73	14	5	1
9	38766	14104	23955	36684	37139	40807	28689	29042	19813	29467
10	305	1304	397	363	394	192	217	206	214	199
11	90	372	62	99	88	93	39	34	17	42
12	13	116	10	4	4	9	5	3	4	6
13	283	483	347	266	322	335	165	163	180	178
14	84	375	74	103	78	101	48	39	20	48
15	32	666	16	46	26	49	10	9	4	6
16	256	454	317	254	265	178	191	207	180	180
17	0	15	0	0	0	0	0	0	0	0
18	55	333	86	61	64	63	40	38	74	41
19	96	319	128	85	134	119	54	63	59	70
20	1817	1910	2929	2103	1899	2187	3237	3238	3697	7645
21	30	244	17	27	31	30	4	5	1	9
22	6	37	2	2	1	1	2	1	1	2
23	5701	7184	7693	6006	6241	6574	4562	4506	6325	5090
24	73	171	64	56	89	73	51	44	32	46
25	86	384	44	74	72	77	26	20	15	24
26	25181	15813	26908	25344	26154	27199	20449	21395	2368	22494
27	8596	13888	12039	7127	9476	11986	9249	9347	12580	96657
28	84	778	61	79	83	101	46	43	35	55
29	0	19	0	0	1	0	0	0	0	1
30	83	172	77	78	67	73	30	39	38	49
31	7	34	5	10	6	17	3	7	1	1
32	1	21	0	0	1	1	0	0	0	1
33	55	120	53	69	61	70	90	21	21	31
34	30	244	17	27	31	30	4	5	1	9
35	177	1353	829	172	11168	3	33	23	23955	397

However, it has also been observed that LBP have not shown expected results for the faces where there are shadow affects. In future, the proposed work can be extended for large number of images and with modified LBP to make it more robust so that it can tackle even large variations in illumination and also shadow affects.

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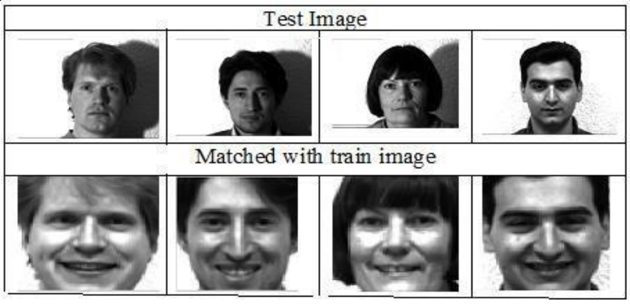

Fig. 12 Unmatched faces

In figure 13 shows a sample result of unmatched images. These images are not matched with the train images from database due to major illumination and shadow problem that can be seen on the left portion of the facial image. This affected the extracted features which in turn degraded the performance of recognition system.

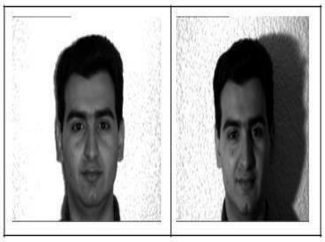

Fig. 13 Unmatched faces

Table 2: Recognition rate of the proposed work

No of train images	No of test images	Matched Images	Unmatched Images	Recognition Rate
25	18	16	2	88.88%

As tabulated in table 2, we achieve the recognition rate of 88.88%. We recognize the face images from the database face images by comparing with the input train face image and the test face image.

V. CONCLUSION

In this paper, we presented a face recognition module using LBP and SVM. Experimentation has been performed on Yale face database. For face detection we have used established Viola-Jones algorithm. The overall recognition rate of the proposed work is 88.88% for the faces under illumination problem. The overall advantage of the proposed work is that there is no pre-processing stage. That in turn saves the time of the proposed work. The result depicts that the LBP features are robust to variation in illumination.

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